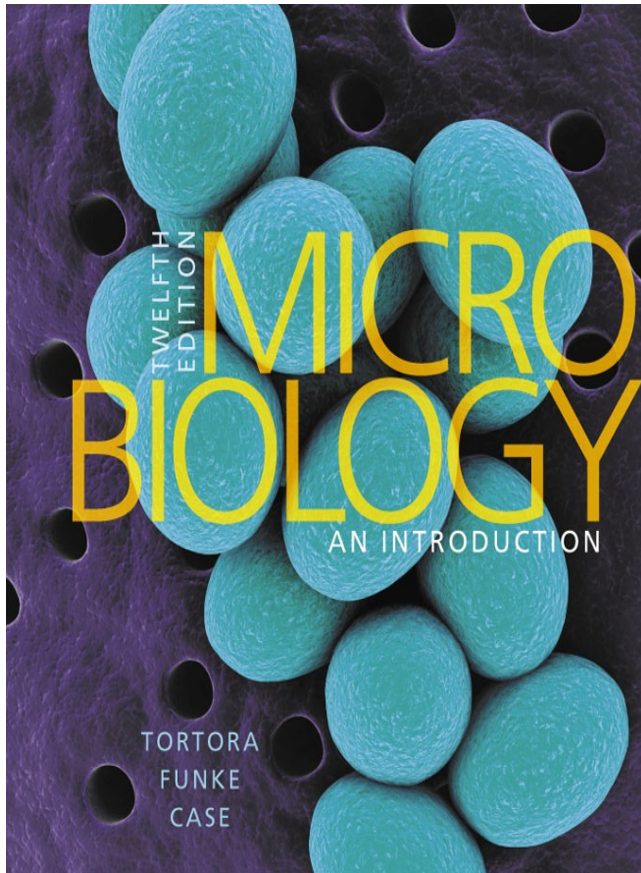


# Microbiology an Introduction

Twelfth Edition



## Chapter 25

### Microbial Diseases of the Digestive System

# Escherichia Coli Bacteria



# Structure and Function of the Digestive System (1 of 3)

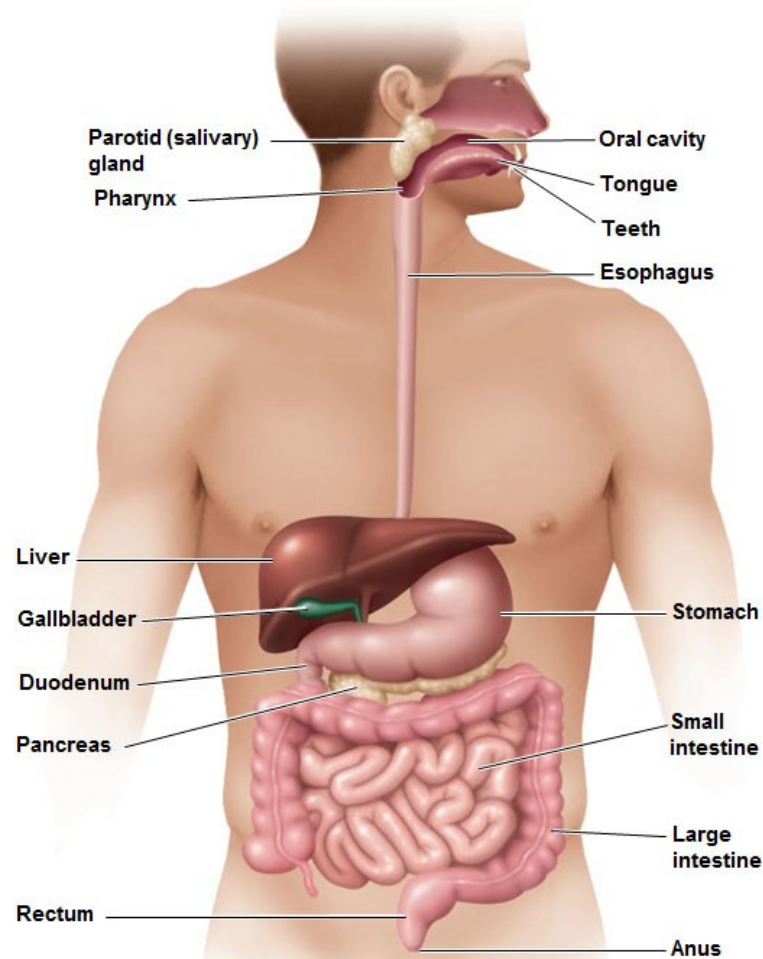
## Learning Objective

25-1 Name the structures of the digestive system that contact food.

# Structure and Function of the Digestive System (2 of 3)

- Gastrointestinal (GI) tract or alimentary canal
  - Mouth
  - Pharynx (throat)
  - Esophagus
  - Stomach
  - Small and large intestine
- Accessory structures
  - Teeth and tongue
  - Salivary glands
  - Liver
  - Gallbladder
  - Pancreas

# Figure 25.1 The human digestive system



# Structure and Function of the Digestive System (3 of 3)

- Absorption of foods
  - 25 tons of food pass through the GI tract in a lifetime
- 80% of the immune system is located in the intestinal tract
  - Gut-associated lymphoid tissue (GALT)
    - Lymph nodes
    - Peyer's patches

# Check Your Understanding-1

## Check Your Understanding

- ✓ Small explosions have occurred when a surgeon used spark-producing instruments to remove intestinal polyps. What ignited?  
25-1

# Normal Microbiota of the Digestive System (1 of 2)

## Learning Objective

25-2 Identify parts of the gastrointestinal tract that normally have microbiota.



# Normal Microbiota of the Digestive System (2 of 2)

- Millions of bacteria per ml of saliva
- Few microorganisms in the stomach
  - Due to HCl production
- Small intestine
  - Paneth cells
    - Granule-filled phagocytic cells; produce defensins
- Large numbers of bacteria in the large intestine
  - Anaerobes and facultative anaerobes
- 100 billion bacteria per gram of feces

# Check Your Understanding-2

## Check Your Understanding

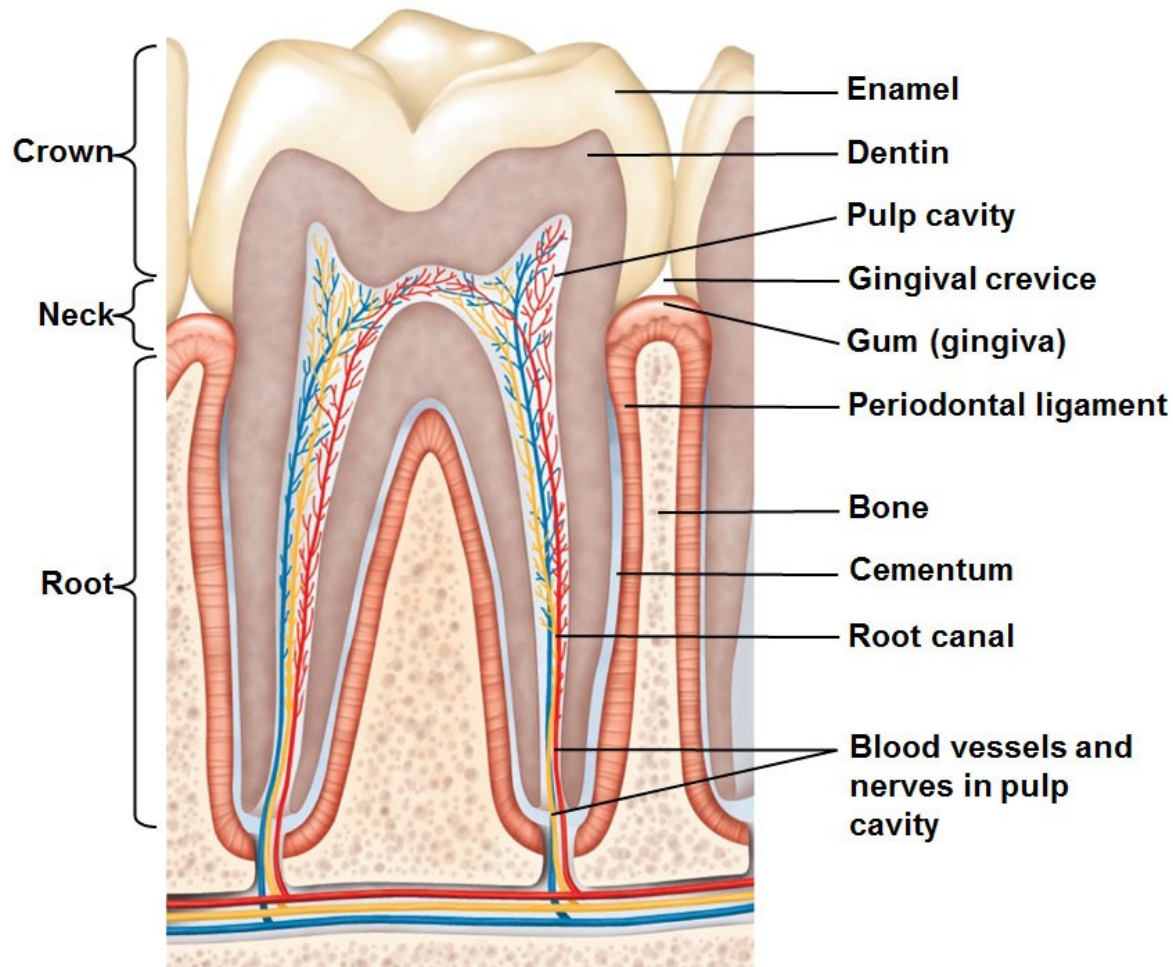
- ✓ How are normal microbiota confined to the mouth and large intestine?  
25-2

# Bacterial Diseases of the Mouth

## Learning Objective

25-3 Describe the events that lead to dental caries and periodontal disease.

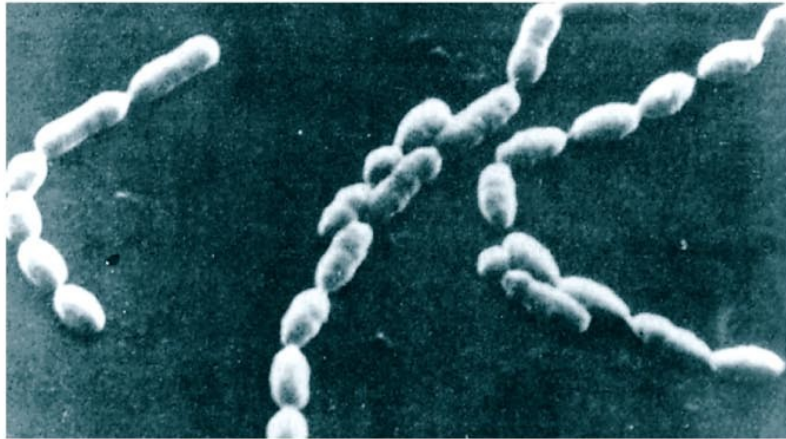
# Figure 25.2 A healthy human tooth



# Dental Caries (Tooth Decay) (1 of 2)

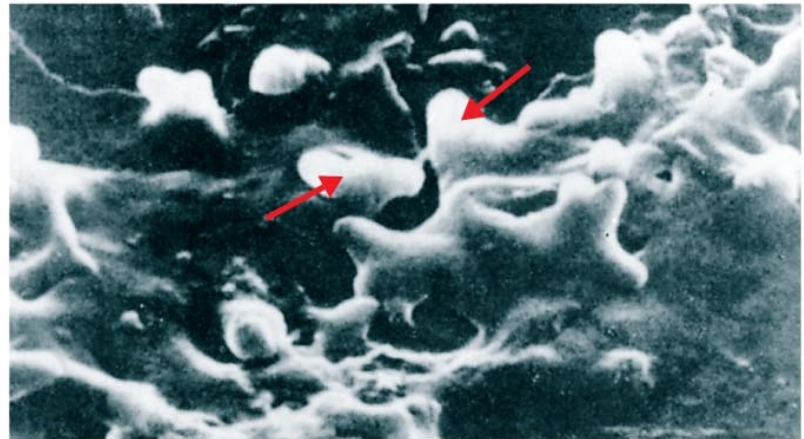
- **Dental plaque**
  - Biofilms involved in the formation of **dental caries**
- 700 species of bacteria in the oral cavity
  - **Streptococcus mutans** is the most important cariogenic organism
    - Gram-positive coccus
    - Converts sucrose to lactic acid
    - Produces dextran, a polysaccharide that forms plaque
- Plaques attract other cariogenic bacteria
  - Streptococci; filamentous **Actinomyces**

# Figure 25.3 Streptococcus mutans



(a) *S. mutans* growing in glucose broth

SEM 1  $\mu$ m



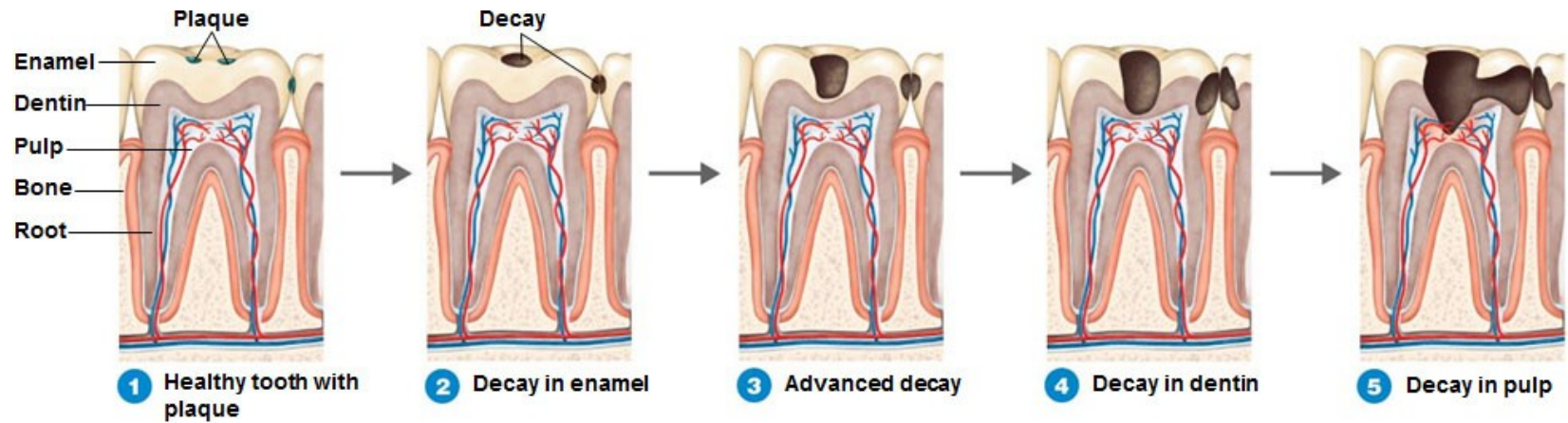
(b) *S. mutans* growing in sucrose broth; note the accumulations of dextran. Arrows point to *S. mutans* cells.

SEM 1  $\mu$ m

# Dental Caries (Tooth Decay) (2 of 2)

- Caries penetrate from enamel into the dentin
  - Caused by gram-positive rods and filamentous bacteria
- Decay can reach pulp, which contains the blood supply and nerve cells
  - May advance to the soft tissues, leading to abscesses
- Introduction of table sugar in the diet is correlated with the level of dental caries

# Figure 25.4 The stages of tooth decay





# Periodontal Disease

- **Gingivitis**

- Inflammation and infection of the gums
- Caused by streptococci, actinomyces, and anaerobic gram-negative bacteria

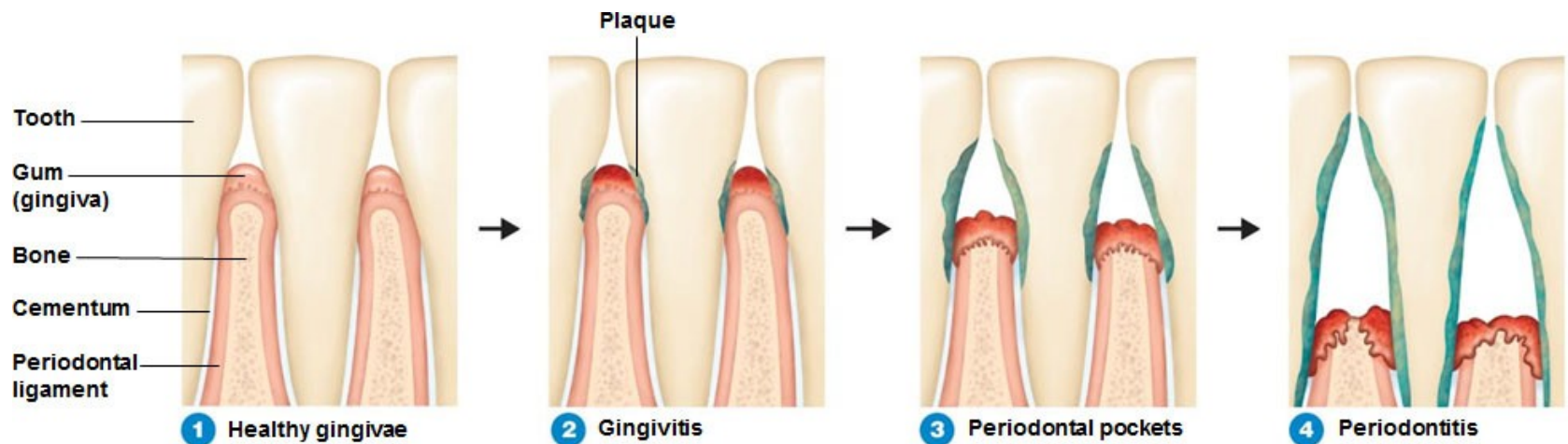
- **Periodontitis**

- Bone and tissue supporting the teeth are destroyed
- Caused by **Porphyromonas**

- **Acute necrotizing ulcerative gingivitis (trench mouth)**

- Caused by **Prevotella intermedia**

# Figure 25.5 The stages of periodontal disease



# Diseases in Focus: Bacterial Diseases of the Mouth

- Can you identify infections that could cause persistent sore, swollen, red, or bleeding gums, as well as tooth pain or sensitivity and bad breath?

# Diseases in Focus 25.1 (1 of 2)



# Diseases in Focus 25.1 (2 of 2)

Disease	Pathogen	Symptoms	Treatment	Prevention
Dental Caries	Primarily <b>Streptococcus mutans</b>	Discoloration or hole in tooth enamel	Remove decayed area	Brushing, flossing, reducing dietary sucrose
Periodontal Disease	Various, primarily <b>Porphyromonas</b> spp.	Bleeding gums, pus pockets	Remove damaged area; antibiotics	Plaque removal
Acute Necrotizing Ulcerative Gingivitis	<b>Prevotella intermedia</b>	Pain chewing, halitosis	Remove damaged area; metronidazole	Brushing, flossing

# Check Your Understanding-3

## Check Your Understanding

- ✓ Why are "sugarless" candies and gum, which actually contain sugar alcohols, not considered cariogenic?  
25-3

# Bacterial Diseases of the Lower Digestive System

## Learning Objective

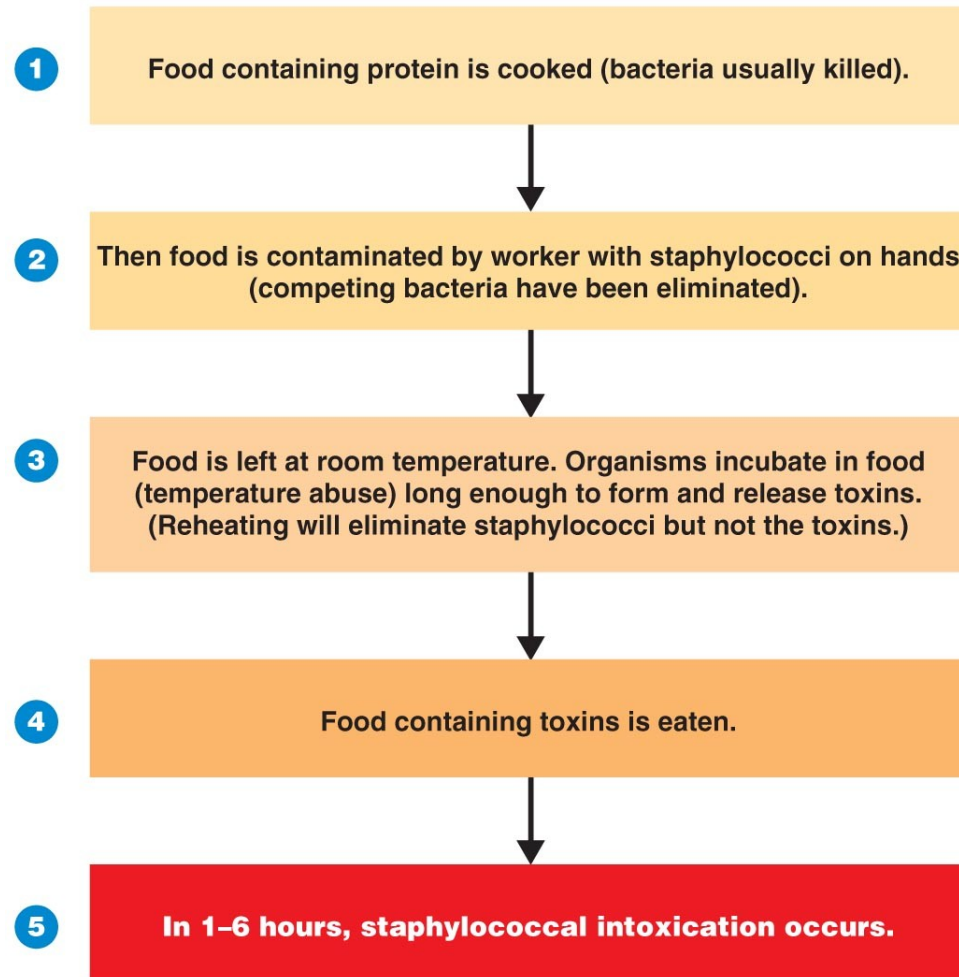
25-4 List the causative agents, suspect foods, signs and symptoms, and treatments for staphylococcal food poisoning, shigellosis, salmonellosis, typhoid fever, cholera, gastroenteritis, and peptic ulcer disease.

# Staphylococcal Food Poisoning (Staphylococcal Enterotoxigenesis)

- Enterotoxin produced by **Staphylococcus aureus**
  - Serological type A
    - Coagulates blood plasma
  - Toxin is not killed by boiling
- Toxins produced when the organism is allowed to incubate in food (**temperature abuse**)
  - **S. aureus** outgrows most bacteria in high osmotic pressure and high temperature
- Phage typing traces sources of contamination



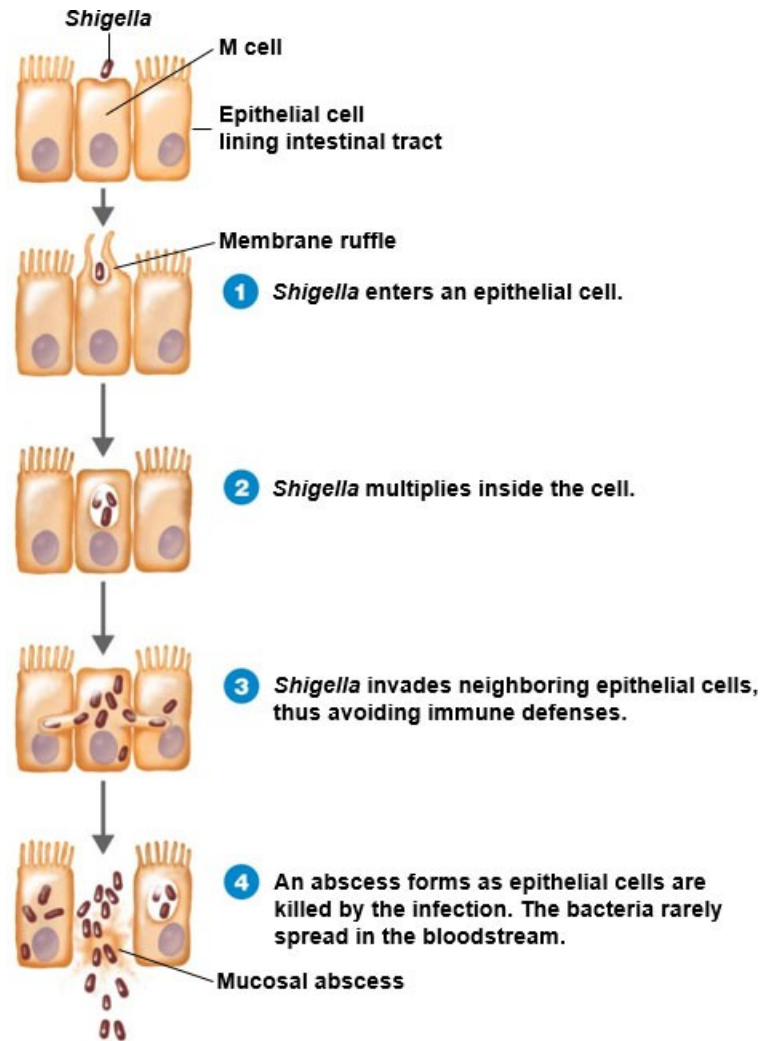
# Figure 25.6 the Sequence of Events in a Typical Outbreak of Staphylococcal Food Poisoning



# Shigellosis (Bacillary Dysentery)

- Caused by the genus **Shigella**
  - Facultatively anaerobic; gram-negative
  - Four species
- Produces the **Shiga toxin**
- Small infectious dose
  - Attaches to M cells, invades, and spreads to other cells
    - Damage to the intestinal wall
    - Can invade the bloodstream
- Treated with fluoroquinolones and oral rehydration

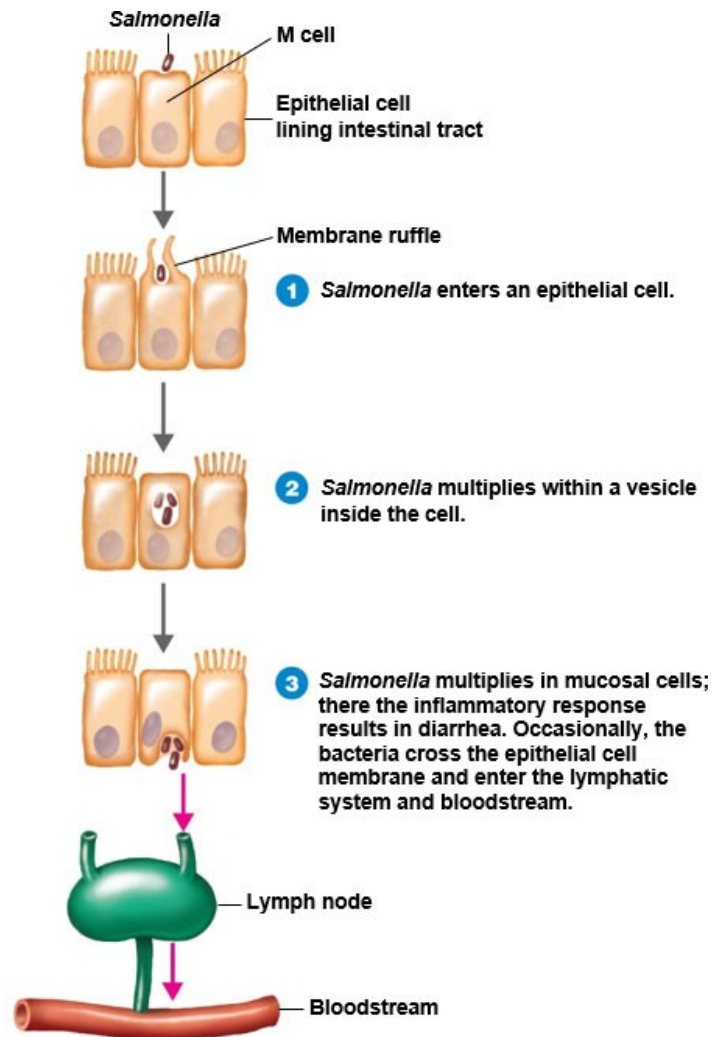
# Figure 25.7 Shigellosis



# Salmonellosis (Salmonella Gastroenteritis) (1 of 2)

- **Salmonella enterica**
  - Gram-negative, facultative anaerobe, nonendospore-forming rods
  - Normal inhabitant of the human intestinal tract
  - 2000 serotypes
- Invades intestinal mucosa and multiplies
  - Passes through M cells and enters the lymphatics
  - Replicates in macrophages
- Incubation of 12 to 36 hours; fever, nausea, pain and cramps, diarrhea

# Figure 25.8 Salmonellosis



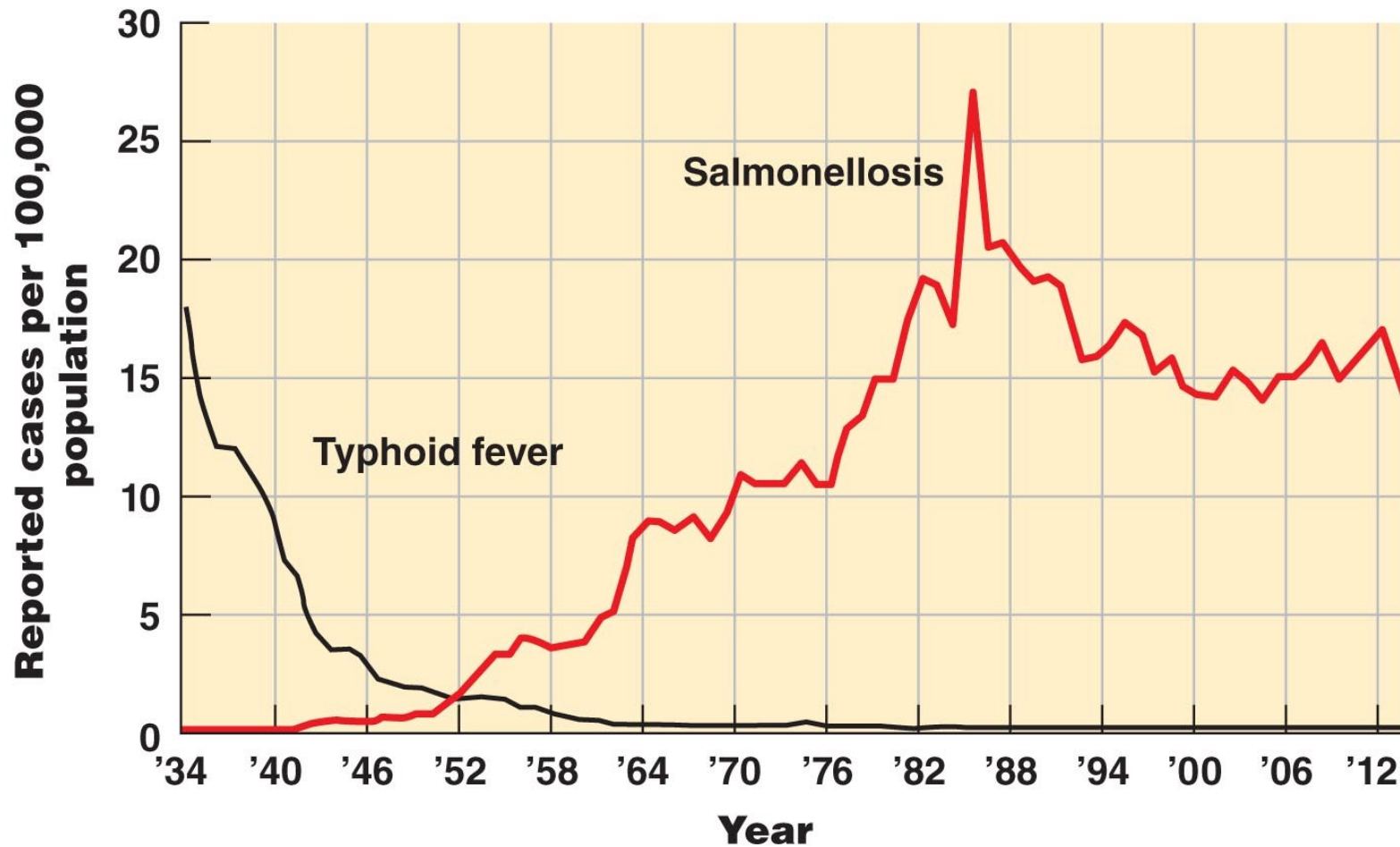
# Salmonellosis (Salmonella Gastroenteritis) (2 of 2)

- 1.4 million cases; 400 deaths annually
- Associated with commercial chicken and egg production
  - Bacteria survive in the albumin
- Diagnosed directly from the stool or by PCR
- Treatment with oral rehydration therapy

# Typhoid Fever

- Caused by **Salmonella typhi**
  - Spread only by human feces
  - Rare in the United States today due to sanitation
- Bacteria spread throughout the body in phagocytes
  - Releases organism into the bloodstream
- High fever, headache, intestinal wall ulceration
- 1–3% of patients become chronic carriers
  - Harbor the organism in the gallbladder
- Treated with chloramphenicol, quinolones, or cephalosporins

# Figure 25.5 The Incidence of Salmonellosis and Typhoid Fever





# Check Your Understanding-4

## Check Your Understanding

- ✓ Why was typhoid fever almost entirely eliminated in developed countries by modern sewage treatment whereas salmonellosis has not been?  
25-4

# Cholera

- Caused by **Vibrio cholerae**
  - Slightly curved, gram-negative rod with single polar flagellum
  - Associated with salty waters
  - Produces the cholera toxin
    - Toxin causes the host cells to secrete electrolytes and water
    - Causes "rice water stools"
- Can lose 12 to 20 liters of fluid per day
  - Causes shock, collapse, organ failure, and death
- Treatment includes IV fluid replacement

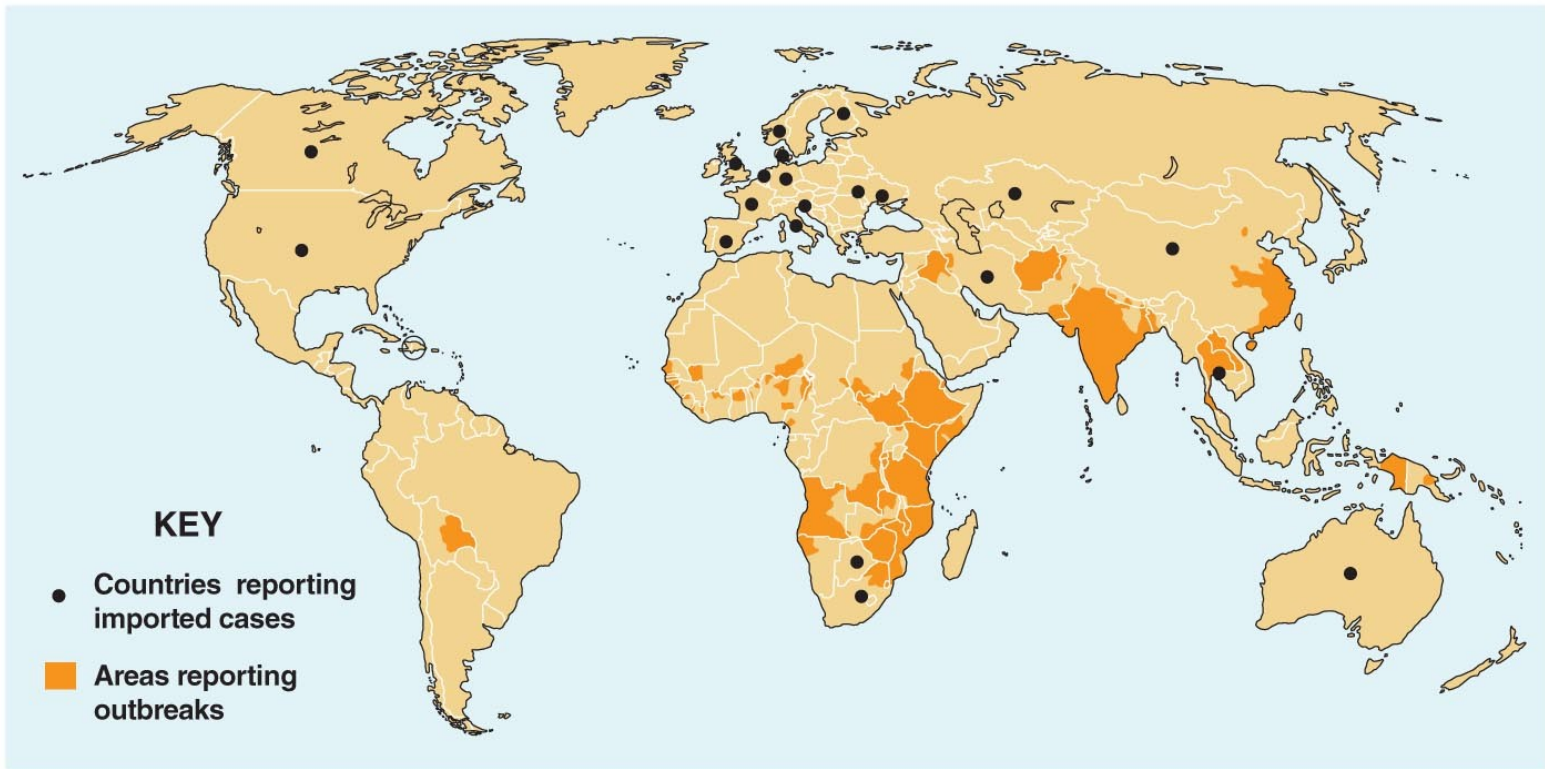
# Figure 25.10 *Vibrio Cholerae*, the Cause of Cholera



# Big Picture: Cholera after Natural Disasters (1 of 2)

- Cholera increases when sanitation and sewage disposal systems are compromised
- Outbreak in Haiti after earthquake due to deficient septic system at the Nepalese base
  - Nepalese soldiers were part of the United Nations peacekeeping force

# Big Picture pg. 720



# Big Picture: Cholera after Natural Disasters (2 of 2)

- Strategies for disaster preparedness
  - Oral rehydration solutions
    - Salt, sugar, and water
  - Stockpiling vaccines
- The ultimate solution
  - Proper sanitation, water storage, handwashing

# Noncholera Vibrios

- Mostly adapted to salty coastal waters
  - **Vibrio parahaemolyticus**
    - Found in saltwater estuaries; common cause of gastroenteritis
    - Raw oysters and crustaceans are associated with outbreaks
- Require early antibiotic therapy

# Escherichia coli Gastroenteritis

(1 of 2)

- **Enteropathogenic E. coli (EPEC)**
  - Diarrhea in developing countries
  - Cause the host cells to form pedestals where the bacteria attach
- **Enteroinvasive E. coli (EIEC)**
  - Causes Shigella-like dysentery
- **Enteraggregative E. coli (EAEC)**
  - Only in humans
  - Produce an enterotoxin causing watery diarrhea



# Figure 25.11 Pedestal formation by Enterohemorrhagic E. coli (EHEC) O157:H7



SEM | 0.5  $\mu\text{m}$

# Escherichia coli Gastroenteritis

(2 of 2)

- **Enterohemorrhagic E. coli (EHEC)**
  - Produces Shiga-like toxin
    - Released upon the cell's lysis
  - Most outbreaks are due to serotype O157:H7
  - Cattle are the main reservoir
  - Causes hemorrhagic colitis and hemolytic uremic syndrome
  - Diagnosed by the inability to ferment sorbitol and pulsed-field gel electrophoresis

# Traveler's Diarrhea

- Most common cause is ETEC; second most common is EAEC
- Can also be caused by **Salmonella, Shigella, and Campylobacter**
- Oral rehydration therapy and bismuth-containing preparations

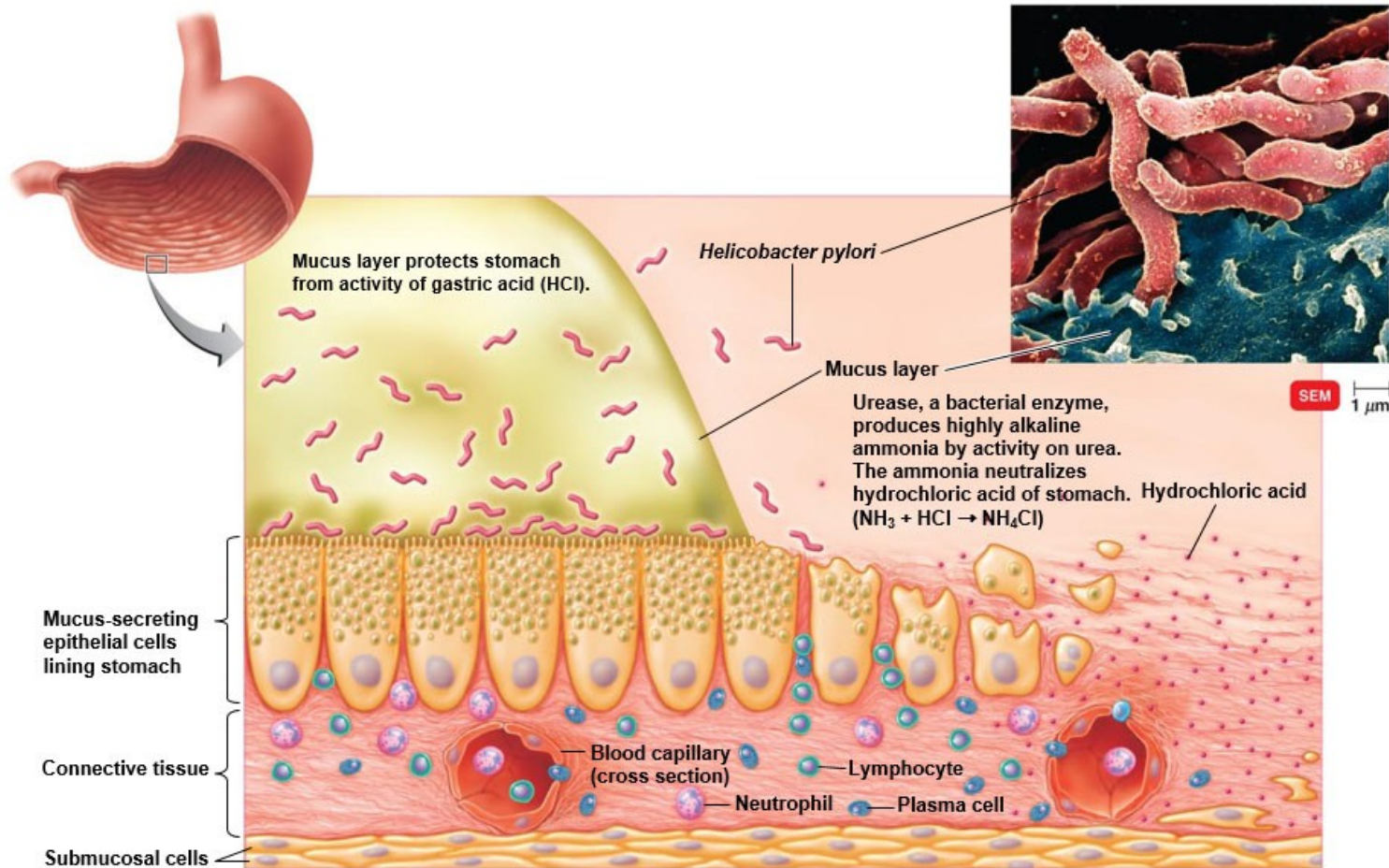
# Campylobacter Gastroenteritis

- Caused by **Campylobacter jejuni**
  - Gram-negative, microaerophilic, spirally curved
- Leading cause of foodborne illness in United States
  - Common in the intestines of poultry
  - 60% of cattle excrete organism in feces and milk
- Fever, cramping, abdominal pain, diarrhea, dysentery
- 1 in 1000 cases leads to Guillain-Barré syndrome

# Helicobacter Peptic Ulcer Disease

- Caused by **Helicobacter pylori**
  - Infects 30–50% of the population in the developed world
  - Grows in the stomach acid by producing urease
    - Converts urea to alkaline ammonia
  - Disrupts stomach mucosa, causing inflammation
- Treated with antimicrobial drugs and bismuth subsalicylate
- Diagnostic test requires a biopsy, culture, and urea breath test

# Figure 25.12 Helicobacter Pylori Infection, Leading to Ulceration of the Stomach Wall



# Yersinia Gastroenteritis

- Caused by **Yersinia enterocolitica** and **Yersinia pseudotuberculosis**
  - Gram-negative
  - Inhabits animals; transmitted in meat and milk
  - Grows at 4°C
- Diarrhea, fever, headache, abdominal pain
  - Often misdiagnosed as appendicitis
- Treatment with antibiotics and oral rehydration

# Clostridium perfringens

## Gastroenteritis

- Gram-positive, endospore-forming, obligately anaerobic rod
- Also causes gas gangrene
- Associated with foods containing animal intestinal contents
  - Creates low oxygen level
- Produces an exotoxin
- Symptoms are usually mild
  - Occur 8 to 12 hours after ingestion



# Clostridium difficile-Associated Diarrhea

- Gram-positive, endospore-forming anaerobe
- Causes more deaths than all other intestinal infections combined
  - Mostly in health care settings
- Life-threatening colitis
  - Ulceration and perforation of the intestinal wall
- Precipitated by the extended use of antibiotics
  - Eliminates competing intestinal bacteria

# Bacillus cereus Gastroenteritis

- Large, gram-positive, endospore forming
  - Common in soil and vegetation
- Spores survive heating
  - Germinate and produce toxins
    - Different toxins cause different symptoms

# Diseases In Focus: Bacterial Diseases of the Lower Digestive System

- An 8-year-old boy has diarrhea, chills, fever (39.3°C), abdominal cramps, and vomiting for 3 days. The next month, his 12-year-old brother experiences the same symptoms. Two weeks before the first patient became ill, the family had purchased a small (< 10 cm) red-eared slider turtle at a flea market.
- Can you identify infections that could cause these symptoms?

# Diseases in Focus 25.2 (1 of 3)

Disease	Pathogen	Symptoms	Intoxication/ Infection	Diagnostic Test	Treatment
Staphylococcal Food Poisoning	<b>Staphylococcus aureus</b>	Nausea, vomiting, and diarrhea	Intoxication (enterotoxin)	Phage typing	None
Shigellosis (bacillary dysentery)	<b>Shigella spp.</b>	Tissue damage and dysentery	Infection (endotoxin and Shiga toxin, exotoxin)	Isolation of bacteria on selective media	Quinolones
Salmonellosis	<b>Salmonella enterica</b>	Nausea and diarrhea	Infection (endotoxin)	Isolation of bacteria on selective media, serotyping	Oral rehydration
Typhoid Fever	<b>Salmonella typhi</b>	High fever, significant mortality	Infection (endotoxin)	Infection (endotoxin) Isolation of bacteria on selective media, Serotyping	Quinolones; cephalosporins
Cholera	<b>Vibrio cholerae</b> O:1 and O:139	Diarrhea with large water loss	Infection (exotoxin)	Isolation of bacteria on selective media	Rehydration; doxycycline

# Diseases in Focus 25.2 (2 of 3)

Disease	Pathogen	Symptoms	Intoxication/ Infection	Diagnostic Test	Treatment
Vibrio parahaemolyticus Gastroenteritis Vibrio parahaemolyticus Gastroenteritis	<b>V. parahaemolyticus</b>	Cholera-like diarrhea, but generally milder	Infection (enterotoxin)	Isolation of bacteria on 2-4% NaCl	Rehydration; antibiotics
<b>Escherichia coli</b> Gastroenteritis	<b>EPEC, EIEC, EAEC, ETEC</b>	Watery diarrhea	Infection (exotoxins)	Isolation on selective media, DNA fingerprinting	Oral rehydration
Shiga Toxin-Producing Enterohemorrhagic <b>E. coli</b>	<b>E. coli</b> O157:H7	<b>Shigella</b> -like dysentery; hemorrhagic colitis, HUS	Infection, Shiga toxin (exotoxin)	Isolation, sorbitol fermentation test, DNA fingerprinting	Intravenous rehydration, serum electrolyte monitoring
<b>Campylobacter</b> Gastroenteritis	<b>Campylobacter jejuni</b>	Fever, abdominal pain, diarrhea	Infection	Isolation in low O <sub>2</sub> , high CO <sub>2</sub>	None
<b>Helicobacter</b> Peptic Ulcer Disease	<b>Helicobacter pylori</b>	Peptic ulcers	Infection	Urea breath test, bacterial culture	Antimicrobial drugs

# Diseases in Focus 25.2 (3 of 3)

<b>Yersinia Gastroenteritis</b>	<b>Yersinia enterocolitica</b>	Abdominal pain and diarrhea, usually mild; may be confused with appendicitis	Infection (endotoxin)	Culture, serotyping	Oral rehydration
<b>Clostridium perfringens Gastroenteritis</b>	<b>Clostridium perfringens</b>	Usually limited to diarrhea	Infection (exotoxin)	Isolation of bacteria	Oral rehydration
<b>C. difficile-Associated Diarrhea</b>	<b>Clostridium difficile</b>	Mild diarrhea to colitis; 1-2.5% mortality	Infection (exotoxin)	Cytotoxin assay	Metronidazole, vancomycin
<b>Bacillus cereus Gastroenteritis</b>	<b>B. cereus</b>	May take form of diarrhea, nausea, vomiting	Intoxication	Isolation of $\geq 10^5$ <b>B. cereus/g</b> food	None

# Viral Diseases of the Digestive System

## Learning Objectives

25-5 List the causative agents, modes of transmission, sites of infection, and symptoms for mumps.

25-6 Differentiate hepatitis A, hepatitis B, hepatitis C, hepatitis D, and hepatitis E.

25-7 List the causative agents, mode of transmission, and symptoms of viral gastroenteritis.

# Mumps

- Virus targets the parotid glands
  - Painful swelling 16 to 18 days after exposure
- Transmitted in the saliva and respiratory secretions
  - Multiplies in respiratory tract and reaches the salivary glands via the bloodstream
- May cause orchitis (swelling of testes), meningitis, ovary inflammation, and pancreatitis
- Prevented with the MMR vaccine



# Figure 25.13 A Case of Mumps



# Check Your Understanding-5

## Check Your Understanding

- ✓ Why is mumps included with the diseases of the digestive system?  
25-5

# Hepatitis

- Inflammation of the liver
- May result from drug or chemical toxicity, Epstein-Barr virus (EBV), cytomegalovirus (CMV), or the hepatitis viruses

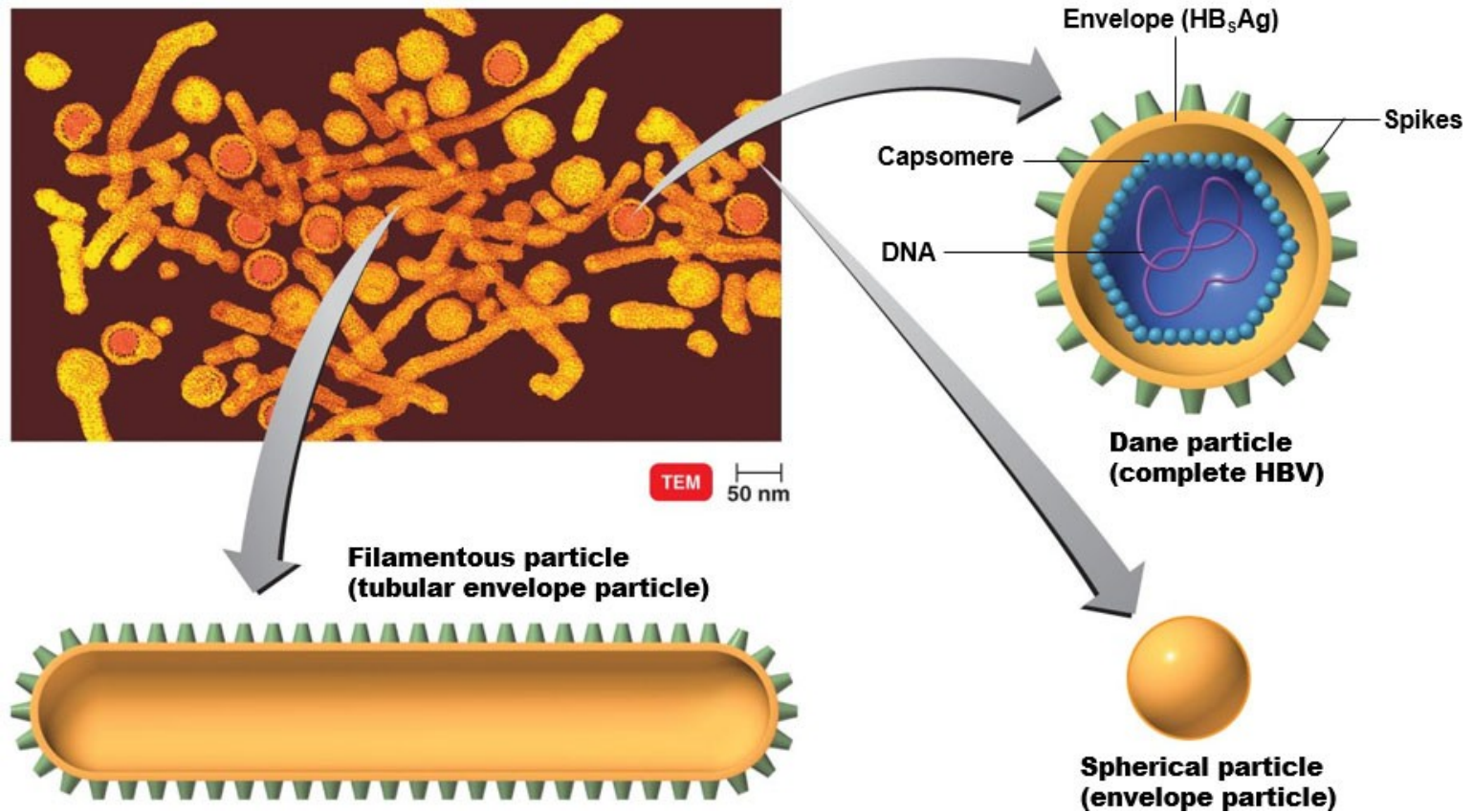
# Hepatitis A

- Hepatitis A virus (HAV)
  - Single-stranded RNA; lacks an envelope
- Entry via the oral route; multiplies in the epithelial lining of the intestinal tract
  - Spreads to the liver, kidneys, and spleen
- Anorexia, malaise, nausea, diarrhea, fever, chills
  - Later, jaundice and dark urine
  - Symptoms last 2 to 21 days; low mortality
- Detected via IgM anti-HAV
- Treated with immune globulin
- Inactivated vaccine for prevention

# Hepatitis B (1 of 2)

- Hepatitis B virus (HBV)
  - Double-stranded DNA; enveloped
  - Resembles retroviruses
- Transmitted via the blood and bodily fluids
  - Up to 1 billion viruses per ml of blood
  - Complete virions (Dane particle)
  - Spherical particles and filamentous particles
    - Lack DNA
    - Contain hepatitis B surface antigen (HB<sub>s</sub>Ag)
- Prevented by a vaccine
- Treated with hepatitis B immune globulin (HBIG)

# Figure 25.14 Hepatitis B virus (HBV)



# Hepatitis B (2 of 2)

- Acute hepatitis B
  - Often subclinical
  - Similar symptoms to hepatitis A; gradual recovery
  - **Fulminant hepatitis** in 1% of cases
    - Sudden massive liver damage; fatal
- Chronic hepatitis B (HB<sub>e</sub>Ag)
  - Involves 10% of infected patients
  - May lead to liver cirrhosis or liver cancer
  - Presence of HB<sub>e</sub>Ag indicates a vigorously replicating virus
  - Treated with interferons and nucleoside analogs

# Hepatitis C

- Hepatitis C virus (HCV)
  - Single-stranded RNA; enveloped
  - Often transfusion-transmitted
- Destroys the liver by using genetic variation to evade the immune response
- Kills more in the United States than AIDS
- 85% of cases become chronic
  - 25% develop liver cirrhosis or cancer
- Treated with peginterferon and ribavirin
- No vaccine



# Diseases in Focus 25.3



# Other Hepatitis Viruses

- **Hepatitis D**

- Acute (coinfection) and chronic (superinfection) forms
- Linked to hepatitis B infection

- **Hepatitis E (HEV)**

- Spread by fecal-oral transmission
  - Similar to hepatitis A
- Endemic in areas with poor sanitation

# Diseases in Focus.

## Characteristics of Viral Hepatitis

- After eating at one restaurant, 355 people were diagnosed with the same hepatitis virus.
- Can you identify infections that could cause these symptoms?

# Diseases in Focus 25.3 (1 of 2)

Disease	Pathogen	Symptoms	Incubation Period	Method of Transmission	Diagnostic Test	Treatment	Vaccine
A	Hepatitis A virus, Picornaviridae	Mostly subclinical; fever, headache; malaise, jaundice in severe cases; no chronic disease	2-6 weeks	Ingestion	IgM antibodies	Immunoglobulin	Inactivated virus. Post-exposure immune Globulin
B	Hepatitis B virus, Hepadnaviridae	Frequently subclinical; similar to HAV, but no headache; more likely to progress to severe liver damage; chronic disease occurs	4-26 weeks	Parenteral; sexual contact	IgM antibodies	Interferon alpha and nucleoside analogues	Genetically modified vaccine produced in yeast

# Diseases in Focus 25.3 (2 of 2)

Disease	Pathogen	Symptoms	Incubation Period	Method of Transmission	Diagnostic Test	Treatment	Vaccine
C	Hepatitis C virus, Flaviviridae	Similar to HBV, more likely to become chronic	2-22 weeks	Parenteral	PCR for viral RNA	Peginterferon and ribavirin	None
D	Hepatitis D virus, Deltaviridae	Severe liver damage; high mortality rate; chronic disease may occur	6-26 weeks	Parenteral; requires coinfection with hepatitis B	IgM antibodies	None	HBV vaccine is protective
E	Hepatitis E virus, Caliciviridae	Similar to HAV, but pregnant women may have high mortality; no chronic disease	2-6 weeks	Ingestion	IgM antibodies, PCR for viral RNA	None	HAV vaccine is protective

# Check Your Understanding-6

## Check Your Understanding

- ✓ Of the several hepatitis diseases, HAV, HBV, HCV, HDV, and HEV, which two now have effective vaccines to prevent them?  
25-6

# Viral Gastroenteritis

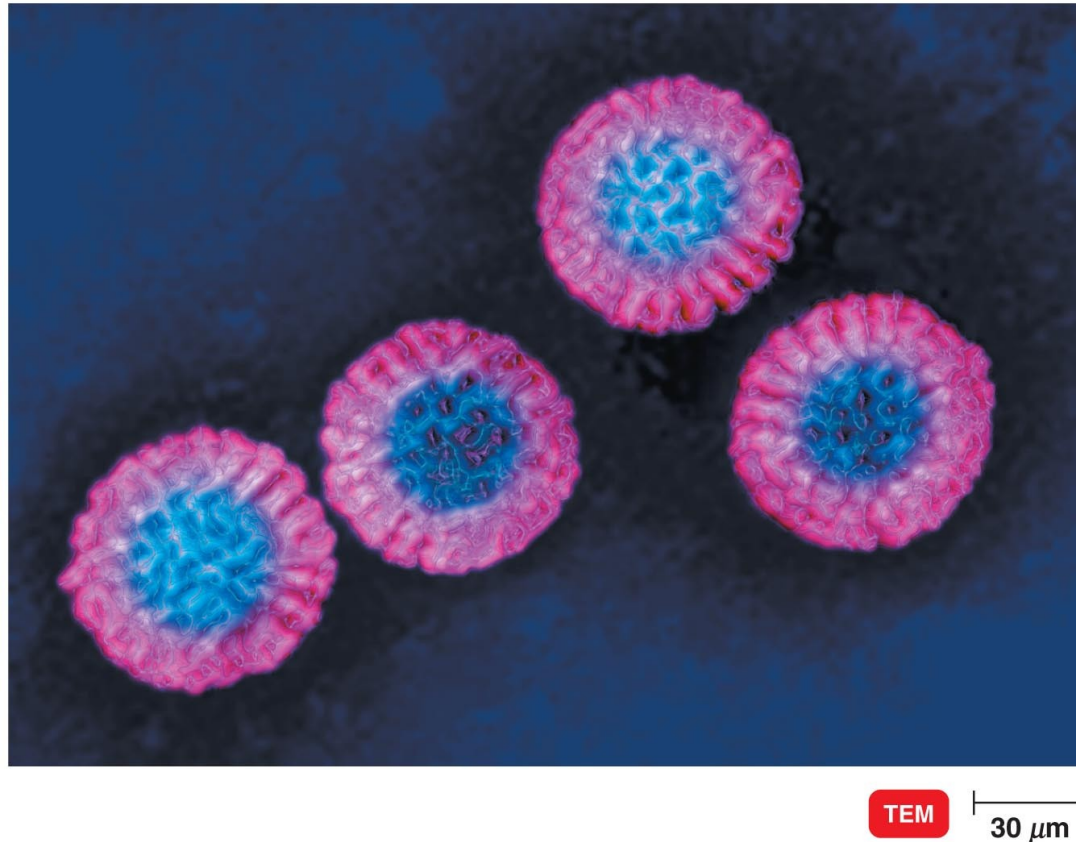
- **Rotavirus**

- Common in children; low mortality
- 2 to 3 day incubation; low-grade fever, diarrhea, vomiting
- Prevented with a live oral vaccine

- **Norovirus**

- Caliciviruses
- Fecal-oral transmission
- Low infectious dose
- 18 to 48 hour incubation; diarrhea and vomiting
- Detected with PCR and EIA tests

# Figure 25.15 Rotavirus





# Check Your Understanding-7

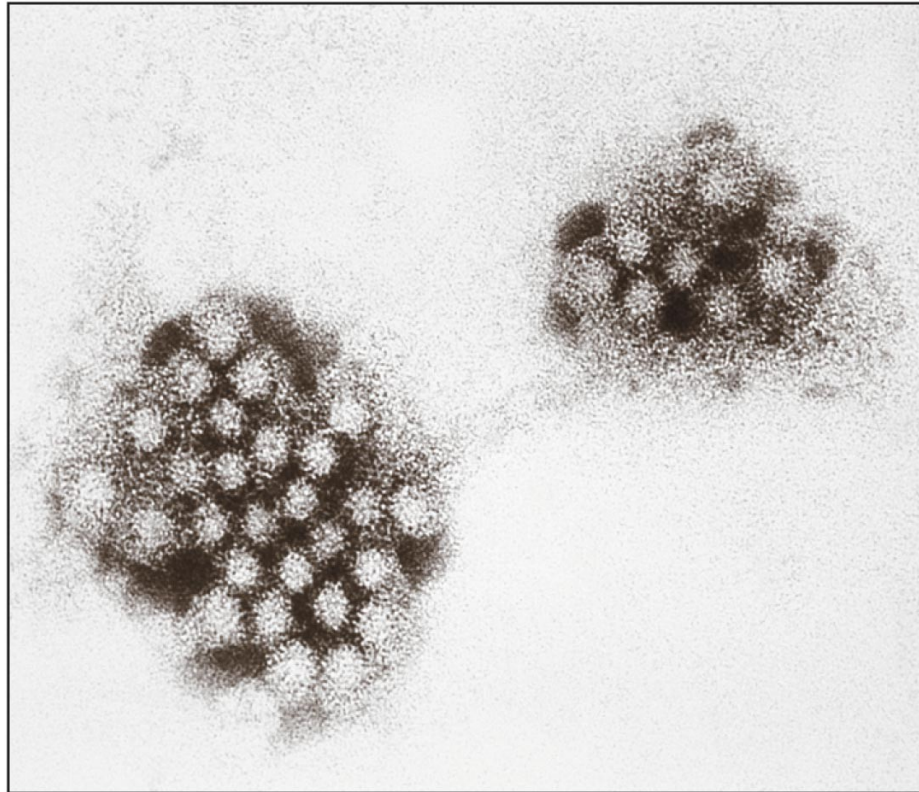
## Check Your Understanding

- ✓ Two very common causes of viral gastroenteritis are caused by rotaviruses and noroviruses. Which of these now can be prevented by a vaccine?  
25-7

# Diseases in Focus: Viral Diseases of the Digestive System

- An outbreak of diarrhea begins in mid-June, peaks in mid-August, and tapers off in September. A clinical case is defined as diarrhea (three loose stools during a 24-hour period) in a member of a swim club. The virus shown is isolated from one patient.
- Can you identify infections that could cause these symptoms?

# Diseases in Focus 25.4 (1 of 2)



TEM 50 nm

# Diseases in Focus 25.4 (2 of 2)

<b>Disease</b>	<b>Pathogen</b>	<b>Symptoms</b>	<b>Incubation Period</b>	<b>Diagnostic Test</b>	<b>Treatment</b>
Mumps	Mumps virus, Paramyxoviridae	Painful swelling of parotid glands	16–18 days	Symptoms; virus culture	Preventive vaccine
Viral Gastroenteritis	<b>Rotavirus</b>	Vomiting, diarrhea for 1 week	1–3 days	Enzyme immunoassay for viral antigens in feces	Oral rehydration
	<b>Noroviruses</b>	Vomiting, diarrhea for 2–3 days	18–48 hr	PCR	Oral rehydration

# Fungal Diseases of the Digestive System (1 of 2)

## Learning Objective

25-8 Identify the causes of ergot poisoning and aflatoxin poisoning.

# Fungal Diseases of the Digestive System (2 of 2)

- Mycotoxins: toxins produced by fungi
  - Blood diseases
  - Nervous system disorders
  - Kidney damage
  - Liver damage
  - Cancer

# Ergot and Aflatoxin Poisoning

- **Ergot poisoning**

- Mycotoxins produced by **Claviceps purpurea**
  - Occurs in grains
  - Restricts blood flow (gangrene) and causes hallucinations

- **Aflatoxin poisoning**

- Mycotoxins produced by **Aspergillus flavus**
  - Likely to be found on peanuts
  - Causes liver cirrhosis and liver cancer

# Check Your Understanding-8

## Check Your Understanding

- ✓ What is the connection between the occasional hallucinogenic symptoms produced by ergot poisoning and a modern illicit drug?  
25-8



# Protozoan Diseases of the Digestive System

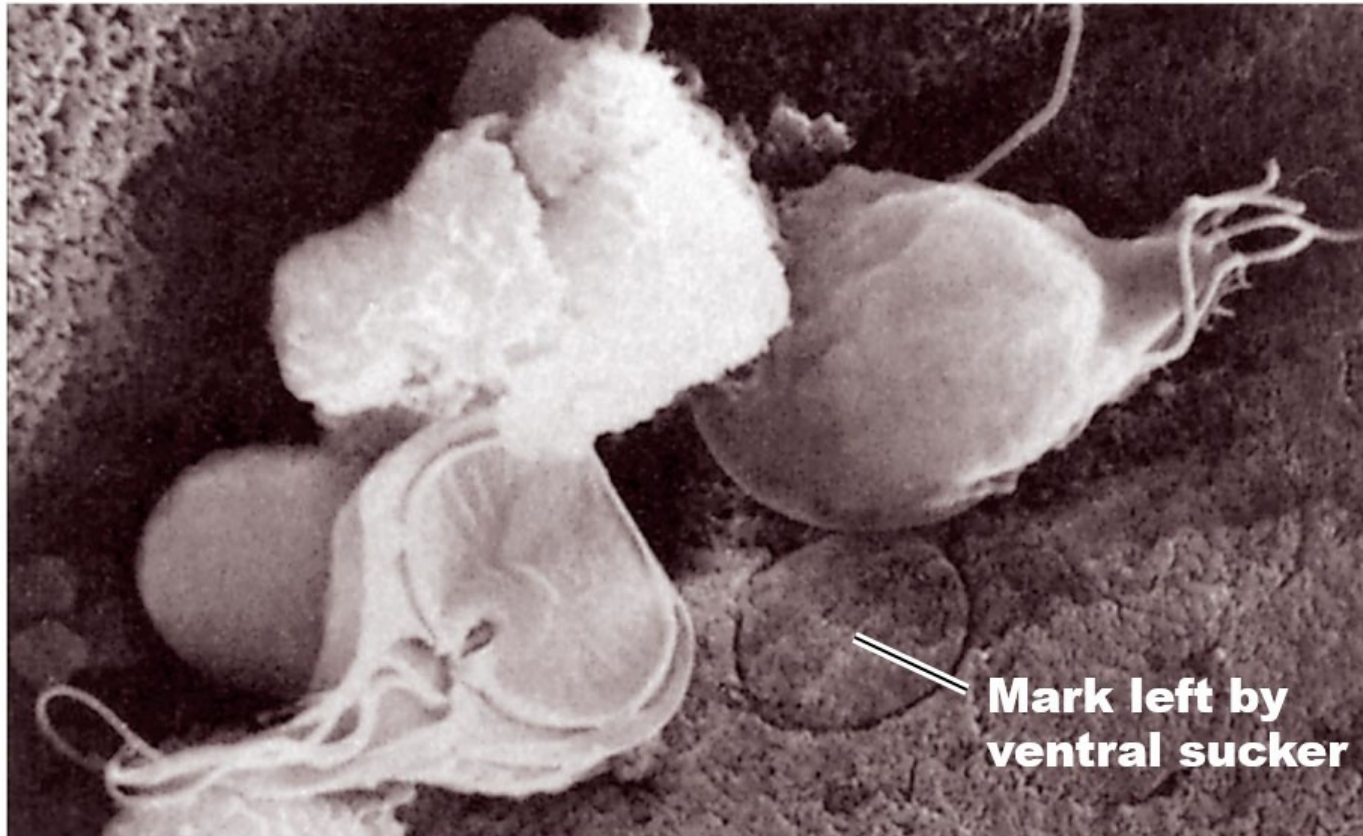
## Learning Objective

25-9 List the causative agents, modes of transmission, symptoms, and treatments for giardiasis, cryptosporidiosis, **Cyclospora** diarrheal infection, and amebic dysentery.

# Giardiasis

- Caused by **Giardia intestinalis**
  - Flagellated protozoan
  - Forms cysts in feces and water; trophozoites in the body
  - Attaches to the intestinal wall
- Prolonged diarrhea, malaise, weight loss, flatulence, cramps
  - Hydrogen sulfide detected in the breath or stools
- Diagnosed with a string test, ELISA, or FA test
- Treated with metronidazole and nitazoxanide

# Figure 25.16 The trophozoite form of *Giardia intestinalis*, the flagellated protozoan that causes giardiasis



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# Check Your Understanding-9

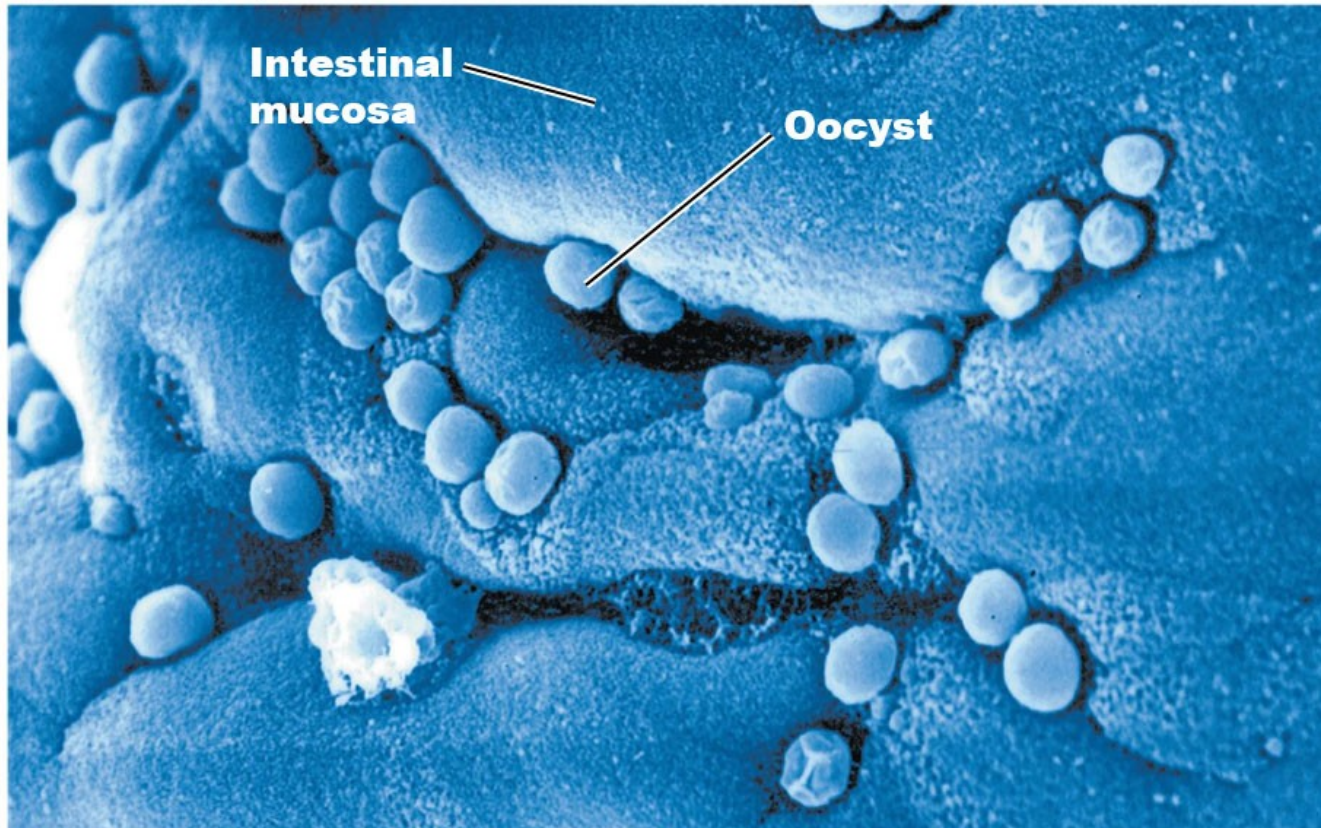
## Check Your Understanding

- ✓ Is giardiasis caused by ingestion of a cyst or an oocyst?  
25-9

# Cryptosporidiosis

- Caused by **Cryptosporidium parvum** and **C. hominis**
- Ingested oocysts release sporozoites
  - Invade the intestinal epithelium
- Cholera-like diarrhea for 10 to 14 days
- Transmitted through drinking water
  - Resistant to chlorination
- Diagnosed with an FA test or immunoassay tests
- Treatment with nitazoxanide

# Figure 25.17 Cryptosporidiosis



SEM 5  $\mu$ m

# Cyclospora Diarrheal Infection

- Caused by **Cyclospora cayetanensis**
- Days or weeks of watery diarrhea
- Oocysts are ingested from drinking water contaminated with feces
- No satisfactory diagnostic tests
- Treatment with trimethoprim and sulfamethoxazole

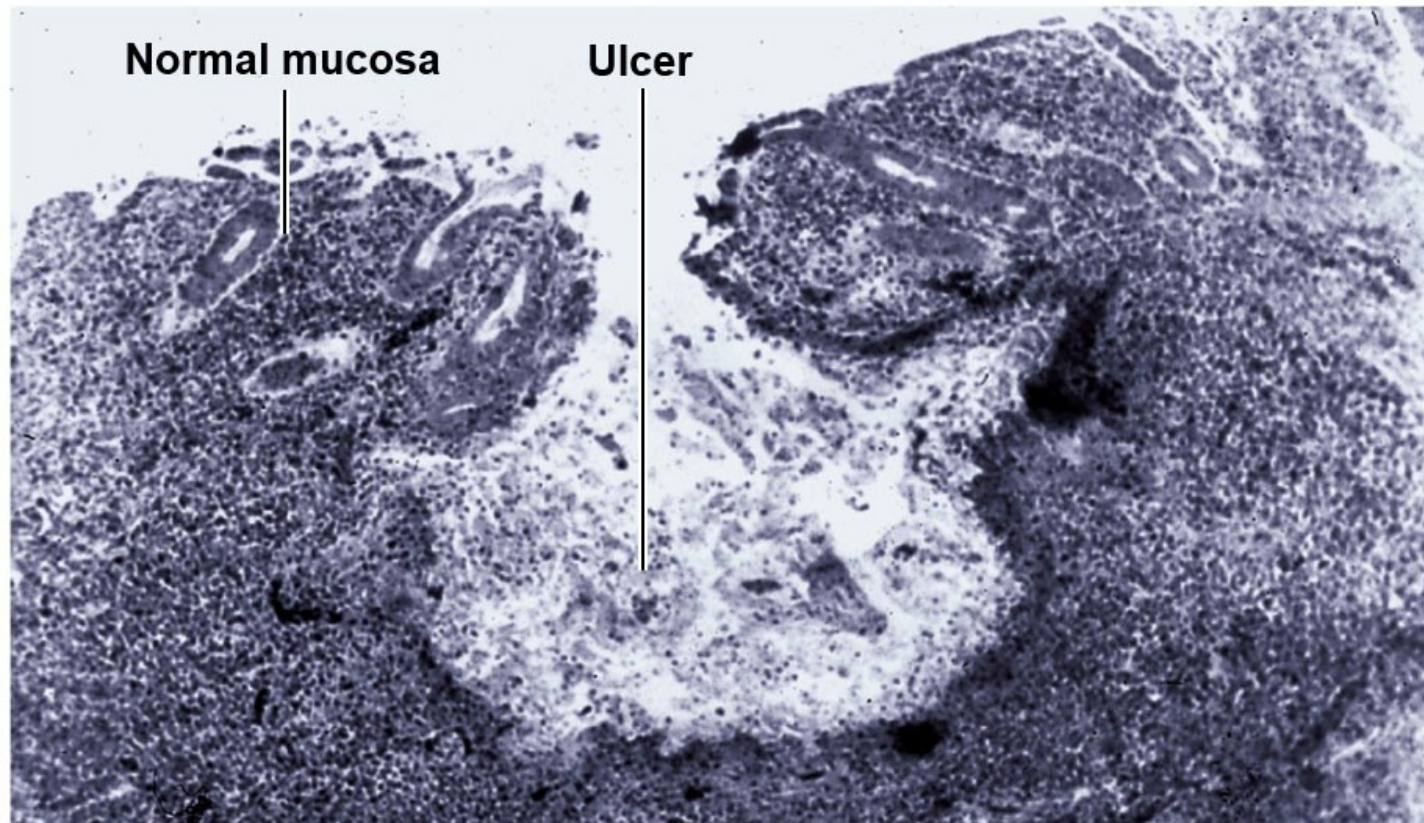


# Amebic Dysentery (Amebiasis)

- Caused by **Entamoeba histolytica**
  - Produces cysts that survive stomach acid
  - Trophozoites produced from cysts in the intestines
    - Multiply in the wall of the large intestine
- Feces contain blood and mucus
- Can perforate the intestinal wall, causing abscesses
  - Organisms invade the liver
- Detection with latex agglutination and FA tests



# Figure 25.18 Section of Intestinal Wall Showing a Typical Flaskshaped Ulcer Caused by *Entamoeba histolytica*



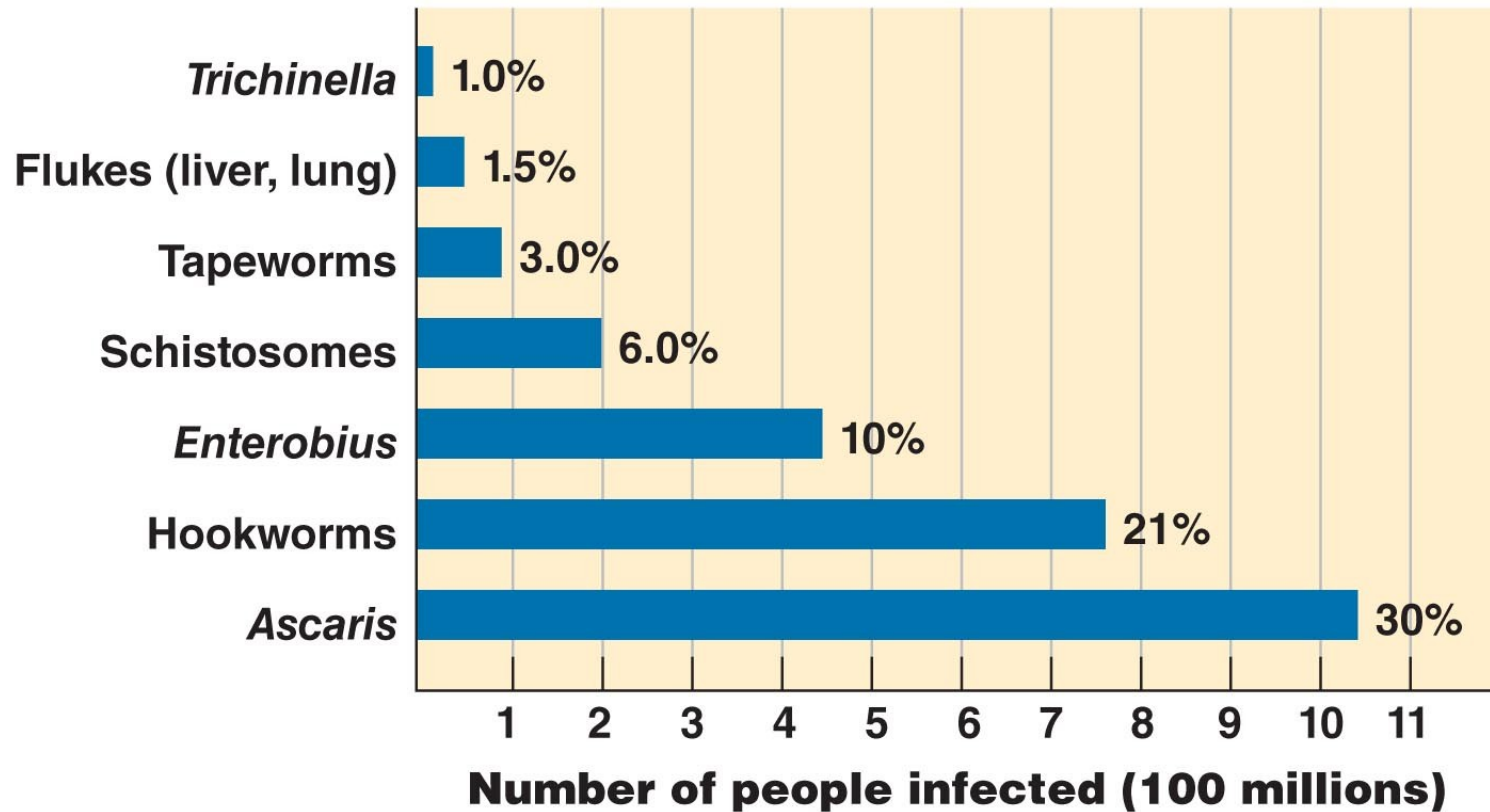
LM | 0.5 mm

# Helminthic Diseases of the Digestive System

## Learning Objective

25-10 List the causative agents, modes of transmission, symptoms, and treatments for tapeworms, hydatid disease, pinworms, hookworms, whipworms, ascariasis, and trichinellosis.

# Figure 25.19 The Worldwide Prevalence of Human Infections with Selected Intestinal Helminths

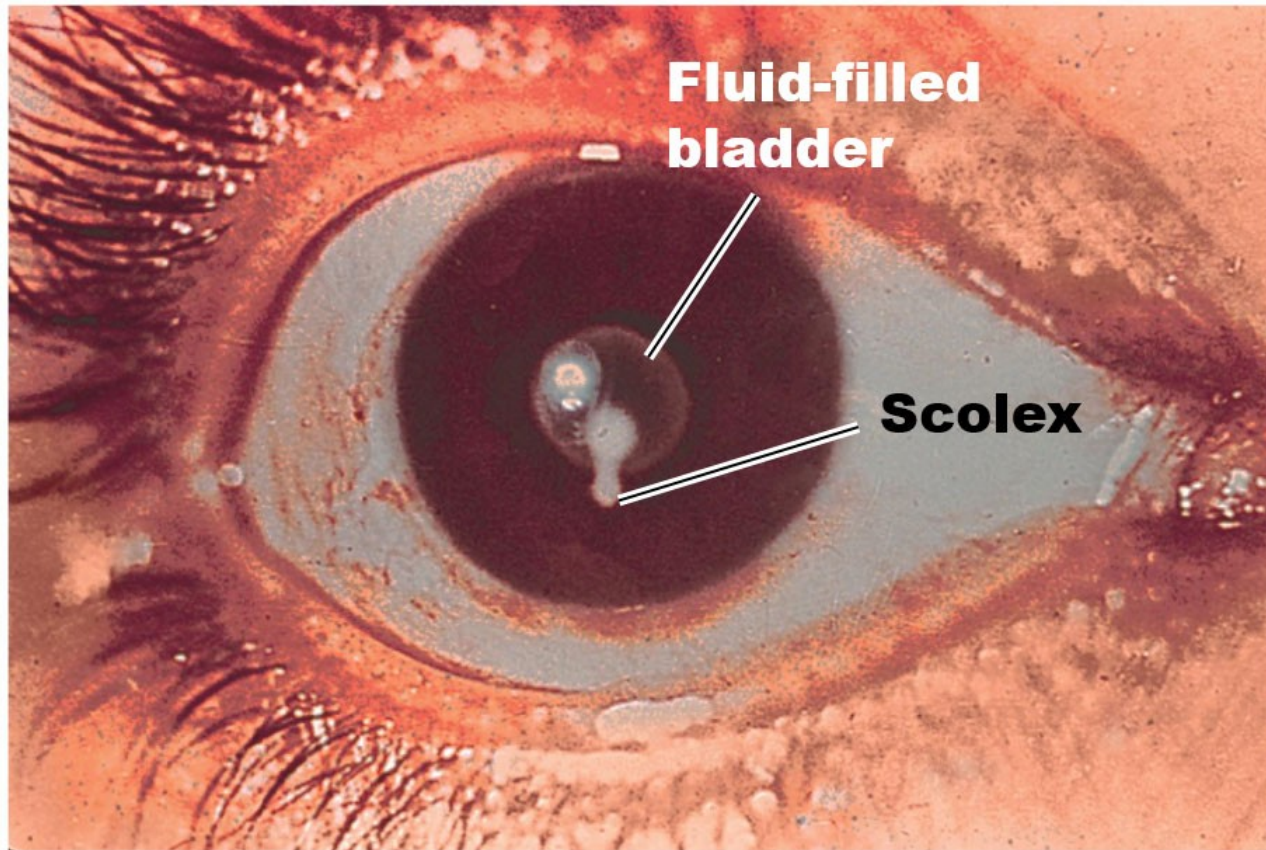


# Tapeworms (1 of 2)

- Beef tapeworm: **Taenia saginata**
- Pork tapeworm: **Taenia solium**
- Fish tapeworm: **Diphyllobothrium latum**
- **Taeniasis:** adult tapeworm infects the intestine
- **Cysticercosis:** infection with the larval stage by ingesting eggs
- **Ophthalmic cysticercosis:** larvae lodge in the eye
- **Neurocysticercosis:** larvae develop in the central nervous system



# Figure 25.20 Ophthalmic Cysticercosis

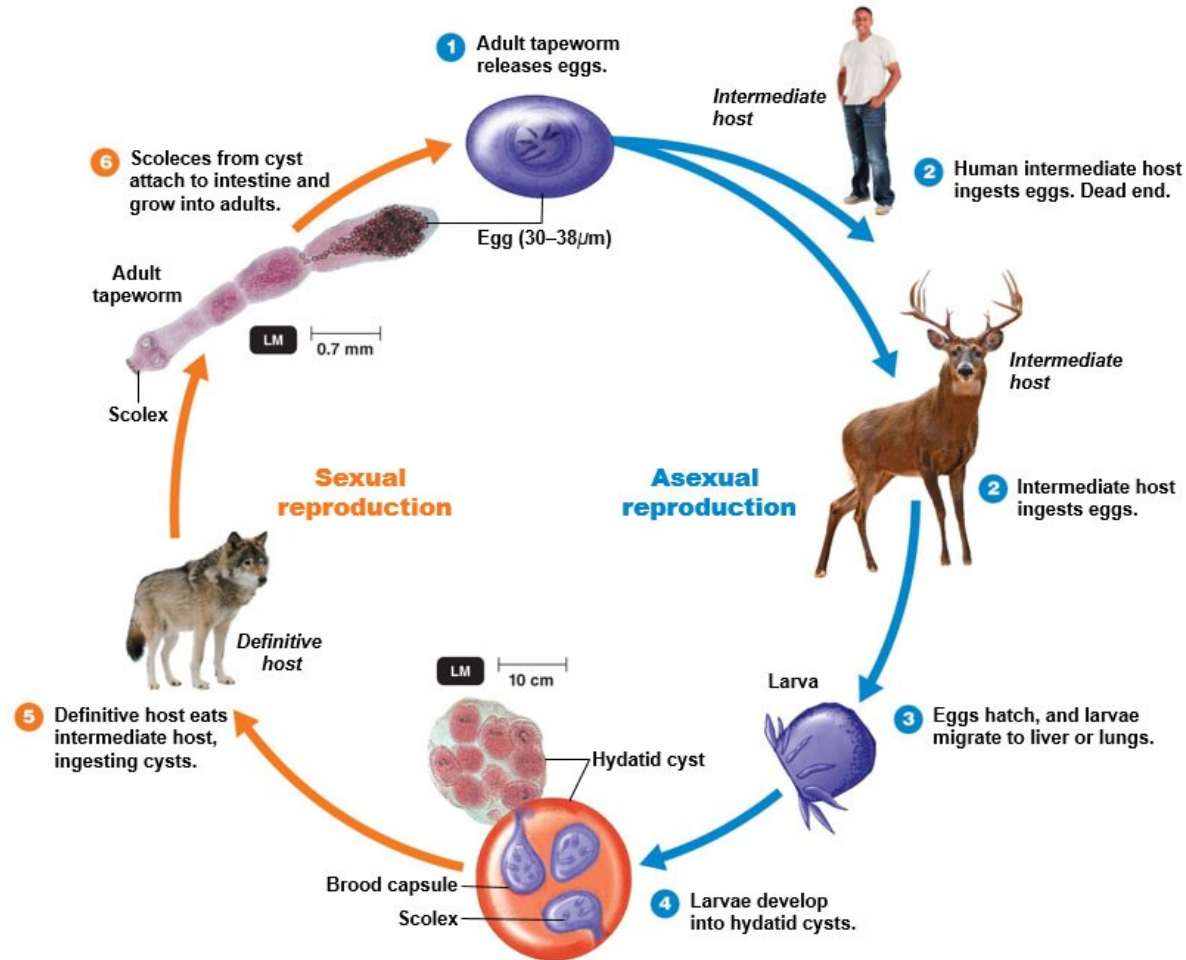




# Tapeworms (2 of 2)

- Three-stage life cycle
  - Eggs are excreted in the feces and ingested by animals
  - Eggs hatch into a larval cysticercus that lodges in the muscle
  - Human ingests undercooked meat containing cysticerci, which develop into adult tapeworms in the intestine
- Diagnosis with eggs or segments in the feces
- Treatment with praziquantel and albendazole

# Figure 12.28 The Life Cycle of the Tapeworm, *Echinococcus* Spp



# Check Your Understanding-10

## Check Your Understanding

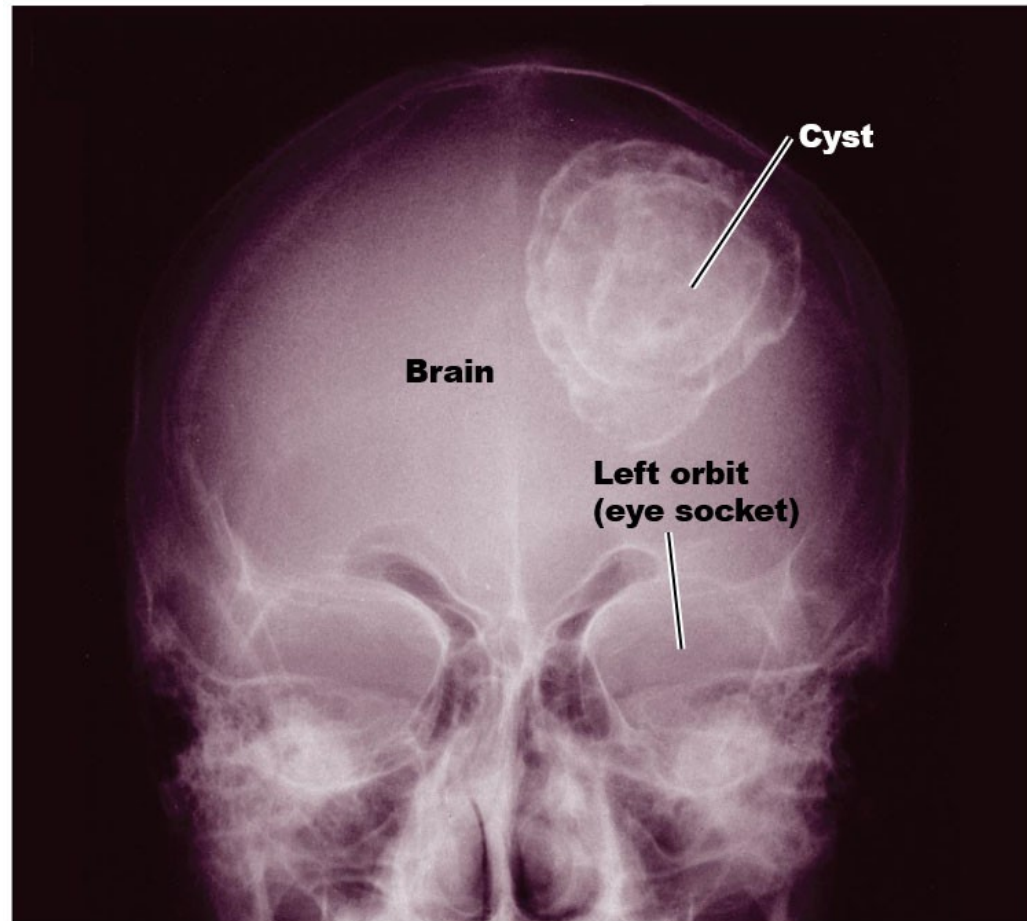
- ✓ What species of tapeworm is the cause of cysticercosis?  
25-10



# Hydatid Disease

- Caused by the tapeworm **Echinococcus granulosus**
- Eggs are ingested and migrate to the liver, lungs, or brain
  - Develops a **hydatid cyst**
    - Can grow and hold up to 15 liters of fluid
    - May rupture, causing anaphylactic shock
- Diagnosis with serological tests, X rays, CT, and MRI
- Treatment with surgical removal or albendazole

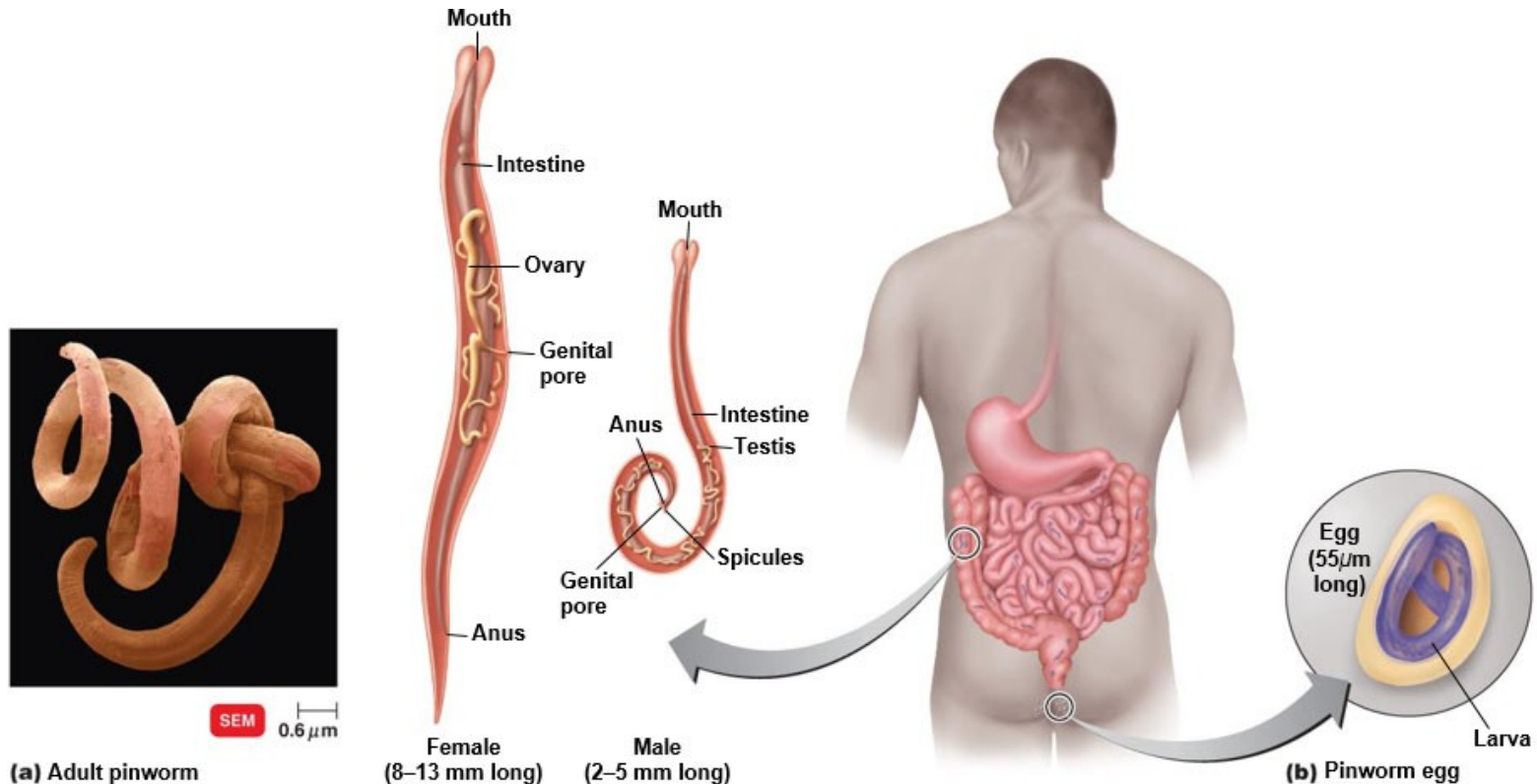
# Figure 25.21 A Hydatid Cyst Formed by Echinococcus Granulosus



# Pinworms

- **Enterobius vermicularis**
  - Tiny nematode
- Lays eggs around the anus, causing local itching
- Treatment with pyrantel pamoate and mebendazole

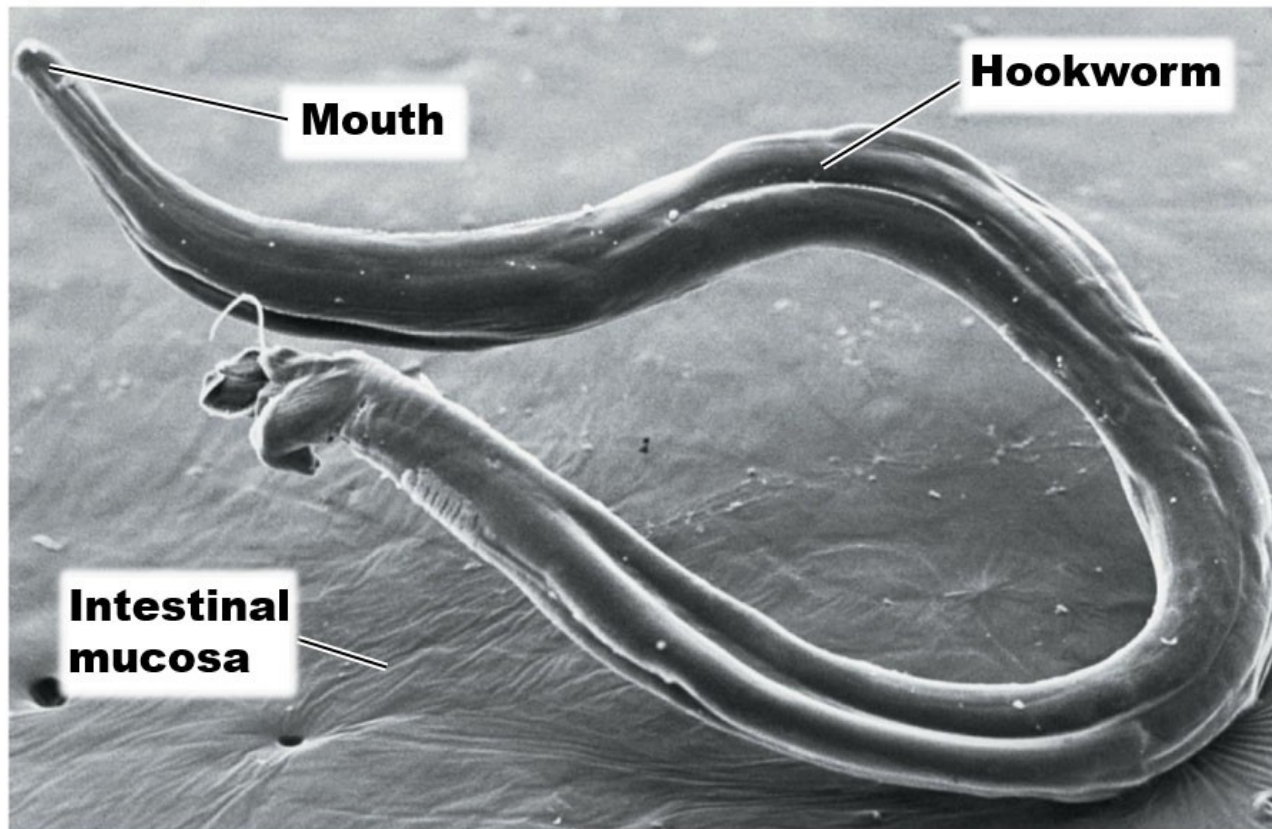
# Figure 12.29 The Pinworm, *Enterobius Vermicularis*



# Hookworms

- Caused by the nematodes **Necator americanus** and **Ancylostoma duodenale**
- Attaches to the intestinal wall and feeds on blood and tissue
- Anemia, lethargic behavior, and craving for peculiar foods (pica)
- Carried from human feces in soil that contact bare skin
- Treatment with mebendazole

# Figure 25.22 Ancylostoma Hookworm



SEM 0.6 mm

# Ascariasis

- Caused by the nematode **Ascaris lumbricoides**
- 30% of the worldwide population is infected
- Eggs shed in the feces and are ingested by another person
  - Hatch into larvae and pass into the bloodstream and lungs
  - Larvae migrate to the throat and are swallowed
  - Larvae develop into adult worms in the intestinal tract and emerge from the anus, mouth, or nose

- Treatment with mebendazole or albendazole

# Figure 25.25 Ascaris Lumbricoides, the Cause of Ascariasis





# Whipworm (*Trichuris trichiura*)

- 30 to 50 mm in length
- Distribution similar to **A. lumbricoides**
- Eggs are ingested and enter the intestinal glands
  - Eggs hatch and grow on the intestinal surface
  - Adult worm buries into the intestinal mucosa and lives as a parasite
    - Feeds on cell contents and blood
- Causes anemia, malnutrition, and retarded growth

# Figure 25.24 Egg of *Trichuris trichiura*

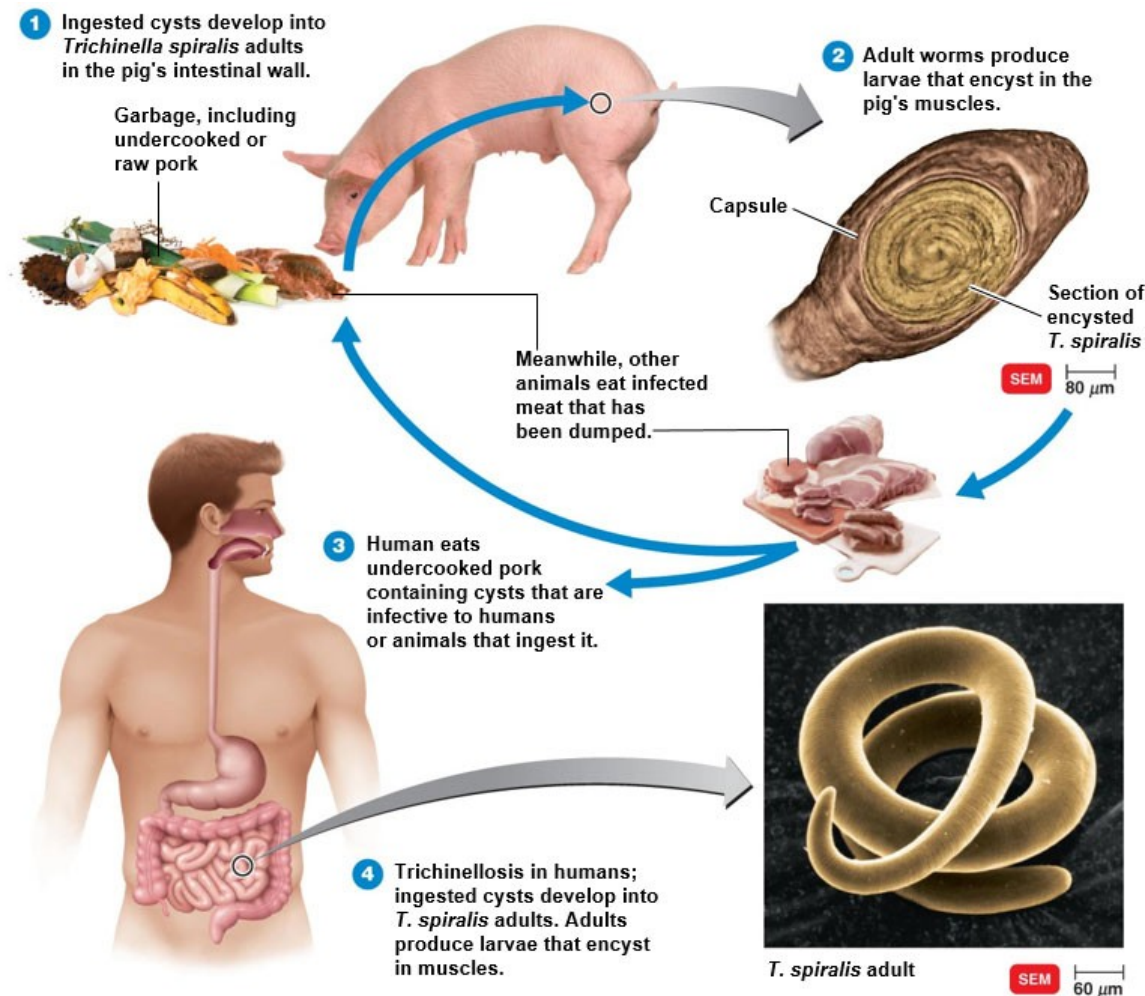


LM | 10  $\mu$ m

# Trichinellosis

- Caused by **Trichinella spiralis**
- Encysted larvae are ingested from undercooked pork and other meats
  - Digestion removes the cyst wall and the worm matures into an adult
  - Adults produce larvae in the intestines that invade tissues and form new cysts
- Fever, eye swelling, gastrointestinal upset
- Treatment with albendazole or mebendazole

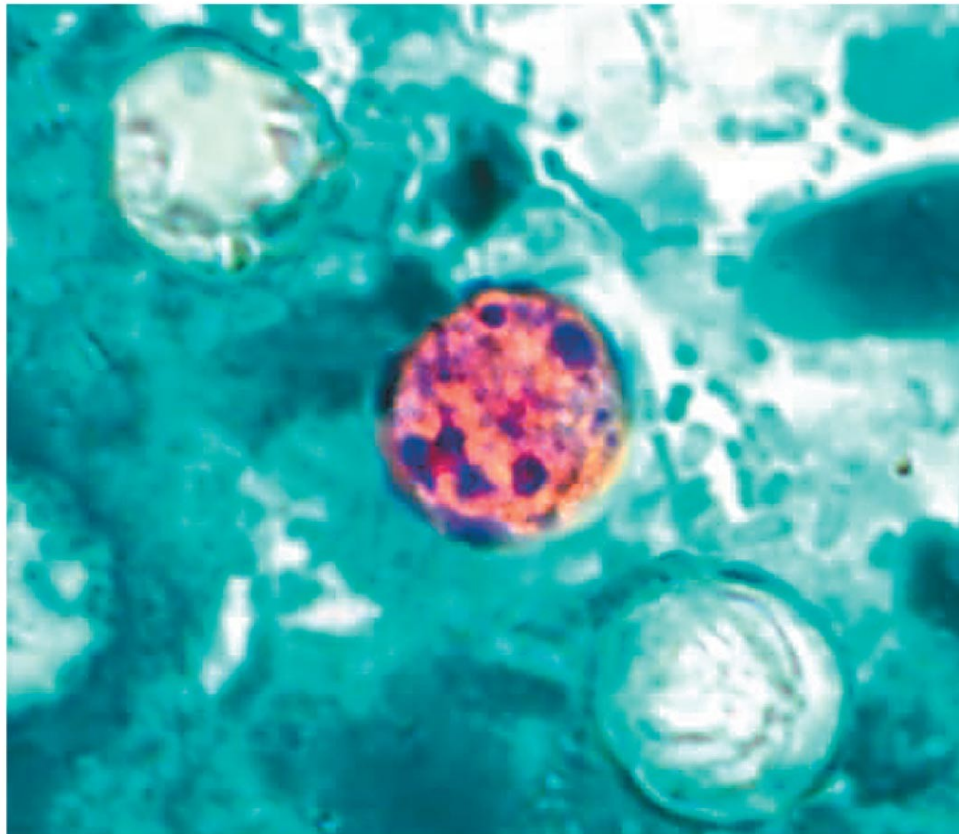
# Figure 25.25 The Life Cycle of *Trichinella Spiralis*, the Causative Agent of Trichinellosis



# Diseases in Focus: Fungal, Protozoan, and Helminthic Diseases of the Lower Digestive System

- Public health officials in Pennsylvania are notified of cases of watery diarrhea with frequent, sometimes explosive, bowel movements among persons associated with a residential facility (e.g., residents, staff, and volunteers). The disease is associated with eating snow peas.
- Can you identify infections that could cause these symptoms?

# Diseases in Focus 25.5 (1 of 4)



LM | 3  $\mu$ m



# Diseases in Focus 25.5 (2 of 4)

Disease	Pathogen	Symptoms	Reservoir or Host	Diagnostic Test	Treatment
<b>Fungal Diseases</b>					
Ergot Poisoning	<b>Claviceps purpurea</b>	Restricted blood flow to limbs; hallucinogenic	Mycotoxin produced by fungus growing on grains	Finding fungal sclerotia in food	None
Aflatoxin Poisoning	<b>Aspergillus flavus</b>	Liver cirrhosis; liver cancer.	Mycotoxin produced by fungus growing on food	Immunoassay for toxin in food	None
<b>Protozoan Diseases</b>					
Giardiasis	<b>Giardia intestinalis</b>	Protozoan adheres to intestinal wall, may inhibit Nutritional absorption; diarrhea.	Water; mammals	FA	Metronidazole; quinacrine
Cryptosporidiosis	<b>Cryptosporidium hominis, C. parvum</b>	Self-limiting diarrhea; may be life-threatening in immunosuppressed	Cattle; water	Acid-fast stain; FA; ELISA	Oral rehydration

# Diseases in Focus 25.5 (3 of 4)

Disease	Pathogen	Symptoms	Reservoir or Host	Diagnostic Test	Treatment
<b>Cyclospora</b> Diarrheal Infection	<b>Cyclospora cayetanensis</b>	Watery diarrhea.	Humans; birds; usually ingested with fruits and vegetables	Acid-fast stain	Trimethoprim and sulfamethoxazole
Amebic Dysentery (amebiasis)	<b>Entamoeba histolytica</b>	Ameba lyses epithelial cells of intestine, causes abscesses; significant mortality rate.	Humans	Microscopy; serology	Metronidazole
<b>Helminthic Diseases</b>					
Tapeworms	<b>Taenia saginata, T. solium, Diphylobothrium latum</b>	Helminth leaves few symptoms; pork tapeworm larvae may encyst in many organs (neurocysticercosis) and cause damage.	Intermediate host: cattle, pigs, fish; definitive host: humans	Microscopic exam of feces	Praziquantel; albendazole
Hydatid Disease	<b>Echinococcus granulosus</b>	Larvae form in body; may be very large and	Intermediate host: humans;	Serology; X-ray exam	Surgical removal; albendazole



# Diseases in Focus 25.5 (4 of 4)

Disease	Pathogen	Symptoms	Reservoir or Host	Diagnostic Test	Treatment
Pinworms	<b>Enterobius vermicularis</b>	Itching around anus.	Intermediate and definitive hosts: humans	Microscopic exam	Pyrantel pamoate
Hookworms	<b>Necator americanus, Ancylostoma duodenale</b>	Large infections may result in anemia.	Larvae enter skin from soil; definitive hosts: humans	Microscopic exam	Mebendazole
Ascariasis	<b>Ascaris lumbricoides</b>	Helminths live off undigested intestinal contents, causing few symptoms.	Intermediate and definitive hosts: humans	Microscopic exam	Mebendazole
Whipworm	<b>Trichuris trichiura</b>	Diarrhea, malnutrition.	Intermediate and definitive hosts: humans	Microscopic exam of feces	Albendazole, mebendazole
Trichinellosis	<b>Trichinella spiralis, T. nativa</b>	Larvae encyst in striated muscle; usually few symptoms, but large infections may be fatal.	Intermediate and definitive hosts: mammals (including humans)	Biopsy; ELISA	Mebendazole ; corticosteroids